THE

JOHN MURRAY EXPEDITION

1933–34

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CONTENTS

PLATES AND CHARTS

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THE FREE-SWIMMING PLANKTONIC COPEPODA

SYSTEMATIC ACCOUNT

BY

R. B. SEYMOUR SEWELL, C.I.E., Sc.D., F.R.S.
(Lieut.-Colonel, I.M.S. [ret.])

WITH SEVENTY-ONE TEXT-FIGURES

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CONTENTS.

INTRODUCTION.

In the present Report I have given an account of the various species of free-living planktonic Copepoda that were obtained by the "John Murray" Expedition and, in addition, I have included records of the capture of certain species that in previous years were obtained by the R.I.M.S. "Investigator" in Indian waters, but in areas lying somewhat to the east of the area investigated by the Expedition in 1933–34.

The species obtained are given below :

Parasites.

A number of species, both surface-living and deep-dwelling forms, were found to be infected with parasites. With (1915) has recorded the presence of certain ectoparasites, the true nature of which appears to be at present unidentified, from the following species :

Chiridius armatus.
Gaidius tenuispinus.
G. brevispinus.
Gætanus kruppi
G. pileatus.
G. latifrons.
Undeuchæta superba.
Chirundina notacantha.

In certain of these the parasite consisted of a short stalk bearing an oval or irregular sac-like body. Similar ectoparasites occurred on a number of species in the present collection. These appear to belong to at least two different forms. In the first group the stalk of the parasite is comparatively long, at least half as long as the terminal cyst, and narrow : this form was present on specimens of the following species :

Gœtanus antarcticus Wolfenden	Sta.	61	depth	1500–0 m.
G. curvicornis Sars	,,	61	,,	1500–0 m.
G. kruppi Giesbrecht	,,	131	,,	1500–0 m.
Euchirella maxima Wolfenden	,,	172	,,	1500–0 m.
E. pulchra (Lubbock)	,,	131	,,	1500–0 m.
Pseudochirella notacantha Sars	,,	61	,,	1500–0 m.
Xanthocalanus greeni Farran	,,	172	,,	1500–0 m.
Lophothrix frontalis Giesbrecht	,,	131	,,	1500–0 m.
Pleuromamma xiphias (Giesbrecht)	,,	172	,,	1500–0 m.

In the second form the parasite consisted of a stalk that was short and broad, very much shorter than half the length of the cyst : this form occurred on the following species :

Bathycalanus bradyi (Wolfenden) juv.	Sta.	131	depth	1500–0 m.
Megacalanus princeps (Wolfenden)	,,	131	,,	1500–0 m.
Gœtanus antarcticus Wolfenden	,,	61	,,	1500–0 m.
G. brevicornis Esterly	,,	131	,,	1500–0 m.
G. kruppi Giesbrecht	,,	131	,,	1500–0 m.
Euchirella maxima Wolfenden	,,	172	,,	1500–0, 450–0 m.
Pseudochirella notacantha Sars	,,	61	,,	1500–0 m.
Onchocalanus affinis With	,,	172	,,	1500–0, 850–0 m.
O. trigoniceps Sars	,,	172	,,	1500–0 m.
Scottocalanus securifrons (T. Scott)	,,	172	,,	820–0 m.
Lophothrix frontalis Giesbrecht	,,	131	,,	1500–0 m.
Amallothrix emarginata (Farran)	,,	172	,,	1500–0 m.
Disseta palumboi Giesbrecht	,,	131	,,	1500–0 m.

These parasites have a close resemblance to early stages in the development of *Ellobiopsis* (*vide* Chatton, 1920, and Steuer, 1928). In the great majority of instances the depth at which these examples were obtained was from hauls in 1500–0 m., the only exceptions being *Euchirella maxima*, from 450–0 m. and *Scottocalanus securifrons* and *Onchocalanus affinis*, from about 850–0 m.

Examples of Acinetids in various stages of growth were observed on the following species :

Euchœta marina (Prestandrea)	Sta.	61	depth	0 m.
E. wolfendeni A. Scott	,,	61	,,	0 m.
Gœtanus antarcticus Wolfenden	,,	61	,,	1500–0 m.
	,,	76	,,	2500–0 m.
G. curvicornis Sars	,,	61	,,	1500–0 m.
Scottocalanus dauglishi Sewell	,,	145	,,	500–0 m.

A number of species taken on the surface at Sta. 61 were found to be infected with examples of *Blastodinium*, and it is interesting to compare the list of these species with that given by Chatton (1920) of species from the Mediterranean Sea that were infected by this parasite :

Mediterranean Sea (from Chatton)	Indian Ocean.
Calanus finmarchicus.	
	Canthocalanus pauper.
	Nannocalanus minor.
	Undinula darwini.
	Paracalanus aculeatus.
Paracalanus parvus	*P. parvus.*
	P. denudatus.
	Acrocalanus gracilis.
Clausocalanus arcuicornis.	*Clausocalanus arcuicornis.*
C. furcatus.	*C. furcatus.*
Pseudocalanus sp.	
Calocalanus styliremis.	*Calocalanus styliremis.*
	Eucalanus pileatus.
	E. subtenuis.
	Euchæta marina.
	E. media.
	E. wolfendeni.
Scolecithrix bradyi.	
Centropages sp.	
Temora stylifera.	
Acartia clausi.	
Oithona plumifera.	*Oithona plumifera.*
O. nana.	
O. simplex.	
	Oncæa clevei.
Oncæa media.	*O. media.*
O. minuta.	
	O. venusta.
	O. venusta var. *vanella.*
	Corycæus speciosus.
*Corycæus venustus.**	
	Corycella gibbula.
Corycella rostrata.	

Chatton's list contains 17 species and that from the Indian Ocean 21 ; six species are common to both lists. It is hoped that a full description of these parasites will be published later.

* The figure that Chatton gives of this species is not that of *venustus*, but may possibly be *Corycæus limbatus.*

List of Species.

CALANOIDA.

Family CALANIDÆ.

Genus Calanus Leach.
Calanus finmarchicus Gunnecrus.

Genus Nannocalanus Sars.
Nannocalanus minor (Claus) f. *major.*
,, ,, ,, f. *minor.*

Genus Calanoides Brady.
Calanoides patagoniensis Brady.

Genus Canthocalanus A. Scott.
Canthocalanus pauper (Giesbrecht).

Genus Neocalanus Sars.
Neocalanus gracilis (Dana).
N. robustior (Giesbrecht).

Genus Undinula A. Scott.
Undinula darwini (Lubbock).
U. vulgaris (Dana).

Genus Megacalanus Wolfenden.
Megacalanus princeps Wolfenden.
,, ,, var. *inermis* nov.

Genus Bradycalanus A. Scott.
Bradycalanus gigas sp. nov.
,, *typicus* A. Scott ? juv.

Genus Bathycalanus Sars.
Bathycalanus bradyi (Wolfenden).

Family EUCALANIDÆ.

Genus Eucalanus Dana.
Eucalanus attenuatus (Dana).
E. pseudattenuatus sp. nov.
E. elongatus (Dana).
E. crassus Giesbrecht.
E. monachus Giesbrecht.
E. mucronatus Giesbrecht.
E. pileatus Giesbrecht.
E. subcrassus Giesbrecht.
E. subtenuis Giesbrecht.

Genus Rhincalanus Dana.
Rhincalanus cornutus Dana, f. *typicus* Schmaus.
R. nasutus Giesbrecht.

Family PARACALANIDÆ.

Genus PARACALANUS Boeck.

Paracalanus aculeatus Giesbrecht.
P. denudatus Sewell.
P. parvus Giesbrecht.

Genus ACROCALANUS Giesbrecht.

Acrocalanus gracilis Giesbrecht.
A. longicornis Giesbrecht.
A. monachus Giesbrecht.

Family PSEUDOCALANIDÆ.

Genus CALOCALANUS Giesbrecht.

Calocalanus pavo (Dana).
C. plumulosus (Claus).

Genus CLAUSOCALANUS Giesbrecht.

Clausocalanus arcuicornis (Dana).
C. farrani Sewell.
C. furcatus (Brady).

Family ÆTIDEIDÆ.

Genus GÆTANUS Giesbrecht.

Gœtanus antarcticus Wolfenden.
G. brevicornis Esterly.
G. curvicornis Sars.
G. kruppi Giesbrecht.
G. latifrons Sars.
G. miles Giesbrecht.
G. minor Farran.
G. pileatus Farran.

Genus EUCHIRELLA Giesbrecht.

Euchirella bella Giesbrecht.
E. galeata Giesbrecht.
E. maxima Wolfenden.
E. orientalis Sewell.
E. pulchra (Lubbock).
E. truncata Esterly.
E. venusta Giesbrecht.

Genus CHIRUNDINA Giesbrecht.

Chirundina indica Sewell.
C. streetsi Giesbrecht.

Genus PSEUDOCHIRELLA Sars.

Pseudochirella magna (Wolfenden).
? *P. notacantha* Sars.
P. obtusa Sars.

Genus Undeuchæta Giesbrecht.

Undeuchæta bispinosa Esterly.
U. major Giesbrecht.

Genus Pseudeuchæta Sars.

Pseudeuchæta brevicauda Sars.

Genus Valdiviella Steuer.

Valdiviella insignis Farran.
V. oligarthra Steuer.

Family EUCHÆTIDÆ.

Genus Euchæta Philippi.

Euchæta consimilis Farran.
E. marina (Prestandrea).
E. media Giesbrecht.
E. murrayi sp. nov.
E. spinosa Giesbrecht.
E. tenuis Esterly.
E. wolfendeni A. Scott.

Genus Paraeuchæta A. Scott.

Paraeuchæta bisinuata Sars.
P. hanseni (With).
P. investigatoris Sewell.
P. malayensis Sewell.
P. sarsi Farran.
P. scotti (Farran).
? *P. spinifera* Esterly.
P. tonsa Giesbrecht.
P. weberi A. Scott.
P. withi sp. nov.

Family PHÆNNIDÆ.

Genus Xanthocalanus Giesbrecht.

Xanthocalanus greeni Farran.

Genus Onchocalanus Sars.

Onchocalanus affinis With.
O. trigoniceps Sars.

Family SCOLECITHRICIDÆ.

Genus Scolecithricella Sars.

Scolecithricella pearsoni Sewell.
S. tenuiserrata (Giesbrecht).

Genus Scottocalanus Sars.
Scottocalanus dauglishi Sewell.
S. helenæ (Lubbock).
S. persecans (Giesbrecht).
S. securifrons (T. Scott).

Genus Scaphocalanus Sars.
Scaphocalanus magnus (T. Scott), f. *major*.
,, ,, ,, f. *minor*.

Genus Lophothrix Giesbrecht.
Lophothrix frontalis Giesbrecht f. *major*.
,, ,, ,, f. *minor*.
L. humilifrons Sars.
L. quadrispinosa Wolfenden.

Genus Amallothrix Sars.
Amallothrix arcuata Sars.
A. emarginata (Farran).
A. gracilis Sars.
A. indica Sewell.

Family CENTROPAGIDÆ.

Genus Centropages Kröyer.
Centropages calaninus (Dana).
C. gracilis (Dana).
C. orsinii Giesbrecht.

Family PSEUDODIAPTOMIDÆ.

Genus Schmackeria Poppe and Richard.
Schmackeria serricaudatus (T. Scott).
Genus Pseudodiaptomus Herrick.
Pseudodiaptomus salinus (Giesbrecht).

Family TEMORIDÆ.

Genus Temora Baird.
Temora discaudata Giesbrecht
T. turbinata (Dana).

Family METRIDIIDÆ.

Genus Metridia Boeck.
Metridia princeps Giesbrecht.

Genus Pleuromamma Giesbrecht.
Pleuromamma abdominalis (Lubbock).
P. indica Wolfenden.
P. quadrungulata (F. Dahl).
P. xiphias (Giesbrecht).

Genus Gaussia Wolfenden.
Gaussia princeps (T. Scott).

Family LUCICUTIIDÆ.

Genus Lucicutia Giesbrecht.
Lucicutia bicornuta Wolfenden.
L. challengeri Sewell.
L. flavicornis (Claus).
L. magna Wolfenden.

Family HETERORHABDIDÆ.

Genus Heterorhabdus Giesbrecht.
Heterorhabdus abyssalis (Giesbrecht).
H. spinifrons (Claus).

Genus Heterostylites Sars.
Heterostylites longicornis (Giesbrecht).

Genus Hemirhabdus Wolfenden.
Hemirhabdus grimaldii (Richard).
H. truncatus (A. Scott).

Genus Mesorhabdus Sars.
Mesorhabdus angustus Sars.

Genus Disseta Giesbrecht.
Disseta palumboi Giesbrecht.

Family AUGAPTILIDÆ.

Genus Haloptilus Giesbrecht.
Haloptilus acutifrons (Giesbrecht).
H. chierchiæ (Giesbrecht).
H. mucronatus (Claus).
H. ornatus (Giesbrecht).
H. oxycephalus (Giesbrecht).
H. validus Sars.

Genus Euaugaptilus Sars.
Euaugaptilus angustus Sars.
E. bullifer (Giesbrecht).
E. digitatus Sars.
E. elongatus Sars.
E. facilis (Farran).
E. grandicornis Sars.
E. indicus Sewell.
E. laticeps Sars.
E. latifrons Sars.
? *E. longicirrhus* Sars.

E. longimanus Sars.
E. magnus (Wolfenden), f. *fungiferus* Steuer.
E. nodifrons Sars.
E. oblongus Sars.
E. penicillatus Sars.
E. tenuispinus Sars.

Genus Augaptilus Giesbrecht.
Augaptilus longicaudatus (Claus).

Genus Centraugaptilus Sars.
Centraugaptilus horridus (Farran).

Family ARIETELLIDÆ.

Genus Arietellus Giesbrecht.
Arietellus giesbrechti Sars.
A. plumifer Sars.
A. simplex Sars.

Genus Phyllopus Brady.
Phyllopus impar Farrar.
P. muticus Sars.

Genus Pachyptilus Sars.
Pachyptilus eurygnathus Sars.
P. lobatus Sars.

Genus Heteroptilus Sars.
Heteroptilus acutilobus Sars.

Family CANDACIIDÆ.

Genus Candacia Dana.
Candacia æthiopica (Dana).
C. bipinnata Giesbrecht.
C. bispinosa (Claus).
C. curta (Dana).
C. longimana (Claus).
C. pachydactyla (Dana).
C. simplex Giesbrecht.
C. varicans Giesbrecht.

Family PONTELLIDÆ.

Genus Calanopia Dana.
Calanopia elliptica (Dana).

Genus Labidocera Lubbock.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
L. minuta Giesbrecht.

Genus PONTELLA Dana.
Pontella fera Dana.
P. securifer Brady.

Genus PONTELLOPSIS Brady.
Pontellopsis armata (Giesbrecht).
P. perspicax (Dana).
P. regalis (Dana).

Genus PONTELLINA Dana.
Pontellina plumata Dana.

Family ACARTIIDÆ.

Genus ACARTIA Dana.

Sub-genus *Acanthacartia* Steuer.
Acartia (*Acanthacartia*) *pietschmani* Pesta.

Sub-genus *Odontacartia* Steuer.
Acartia (*Odontacartia*) *amboinensis* Carl.
A. (*O.*) *erythræa* Giesbrecht.

CYCLOPOIDA.

Section GNATHOSTOMA.

Family OITHONIDÆ.

Sub-family OITHONINÆ.

Genus OITHONA Baird.
Oithona attenuata Farran.
O. brevicornis Giesbrecht.
O. fallax Farran.
O. nana Giesbrecht.
O. oculata Farran.
O. plumifera Baird.
O. rigida Giesbrecht.
O. setigera (Dana).

Section PŒCILOSTOMA.

Family ONCÆIDÆ.

Genus ONCÆA Philippi.
Oncœa clevei Früchtl.
O. conifera Giesbrecht.
O. media Giesbrecht, f. *major*.
,, ,, f. *minor*.
Q. mediterranea Claus.
O. venusta Philippi, f. *typica*.
,, ,, f. *vanella* Farran.

Genus Lubbockia Claus.
Lubbockia aculeata Giesbrecht.

Family SAPPHIRINIDÆ.

Genus Sapphirina Thompson.
Sapphirina angusta Dana.
S. bicuspidata Giesbrecht.
S. iris Dana.
S. nigromaculata Claus.
S. metallina Dana.
S. opalina Dana—*darwini* Haeckel.
S. ovato-lanceolata Dana—*gemma* Dana.
S. sinuicauda Brady.
S. stellata Giesbrecht.

Genus Copilea Dana.
Copilia hendorffi Dahl.
C. lata Giesbrecht.
C. mediterranea (Claus).
C. mirabilis Dana.
,, ,, f. *platyonyx* Lehnhofer.
C. quadrata Dana.
C. vitrea (Haeckel).

Family LICHOMOLGIDÆ.

Genus Pachysoma Claus.
Pachysoma tuberosum Giesbrecht.

Family CORYCÆIDÆ.

Genus Corycæus Dana.

Sub-genus *Corycæus* M. Dahl.
Corycæus (*Corycæus*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.

Sub-genus *Urocorycæus* M. Dahl.
Corycæus (*Urocorycæus*) *longistylis* Dana.

Sub-genus *Ditrichocorycæus* M. Dahl.
? *Corycæus* (*Ditrichocorycæus*) *africanus* F. Dahl.
C. (*D.*) *asiaticus* F. Dahl.
C. (*D.*) *lubbocki* Giesbrecht.

Sub-genus *Onychocorycæus* M. Dahl.
Corycæus (*Onychocorycæus*) *agilis* Dana.
C. (*O.*) *catus* F. Dahl.
C. (*O.*) *pacificus* F. Dahl.
C. (*O.*) *pumilus* M. Dahl.

Sub-genus *Corycella* Farran.
Corycæus (*Corycella*) *gibbulus* Giesbrecht.

HARPACTICOIDA.

Family ECTINOSOMIDÆ.

Genus Ectinosoma Boeck.
Ectinosoma melaniceps Boeck.

Genus Microsetella Brady and Robertson.
Microsetella norvegica (Boeck).
M. rosea Dana.

Family TACHIDIIDÆ.

Genus Enterpina Norman.
Enterpina acutifrons (Dana).

Family MACROSETELLIDÆ.

Genus Macrosetella A. Scott.
Macrosetella gracilis (Dana).
M. oculata (Sars).

Genus Miracia Dana.
Miracia efferata Dana.

Family CLYTEMNESTRIDÆ.

Genus Clytemnestra Dana.
Clytemnestra rostrata (Brady).
C. scutellata Dana.

Family PONTOSTRATIOTIDÆ.

Genus Ægisthus Giesbrecht.
Ægisthus aculeatus Giesbrecht.
Æ. mucronatus Giesbrecht.

In a previous paper (Sewell, 1929–1932) I was able to record from the northern part of the Indian Ocean as many as 17 species that up to that time had not been recorded from any region other than the Atlantic Ocean or the Atlantic section of the Antarctic, namely :

Bathycalanus richardi Sars.
Spinocalanus magnus Wolfenden.
Monacilla tenera Sars.
Gaidius minutus Sars.
Pseudochirella cryptospina Sars.
P. notacantha Sars.
P. magna (Wolfenden).
Valdiviella minor Wolfenden.
V. oligarthra Steuer.
Onchocalanus trigoniceps Sars.
Lophothrix quadrispinosa (Wolfenden).
Scaphocalanus affinis Sars.
Amallothrix arcuata (Sars).
Mesorhabdus angustus Sars.
Euaugaptilus latifrons Sars.
E. tenuispinus Sars.
Pontoptilus ovalis Sars.

Among the present collections there are as many as 21 other species that up to the present time have not been recorded beyond the Atlantic Ocean, namely :

Bathycalanus bradyi Wolfenden.
Gætanus curvicornis Sars.
Pseudeuchæta brevicauda Sars.
Paraeuchæta hanseni (With).
P. scotti (Farran).
P. withi sp. nov. (*sarsi* With, non Farran).
Xanthocalanus greeni Farran.
Lophothrix humilifrons Sars.
Haloptilus validus Sars.
Euangaptilus digitatus Sars.
E. elongatus Sars.
E. grandicornis Sars.
E. longicirrhis Sars.
E. longimanus Sars.
E. penicillatus Sars.
Arietellus giesbrechti Sars.
A. plumifer Sars.
Phyllopus muticus Sars.
Pachyptilus eurygnathus Sars.
P. lobatus Sars.
Heteroptilus acutilobus Sars.

Such a comparatively large number of deep-sea species that are common to the Atlantic and Indian Oceans, but are at present unknown from any other region, indicates that there either is or has been a close connection between these two regions. Formerly (*vide* Alcock, 1898) this resemblance between the two faunas was attributed to the existence in early Tertiary times of the Tethys Sea, but I (*vide* Sewell, 1940) in a previous paper have suggested that the real explanation is to be found in the trend of the deep currents at the present day. I hope in a subsequent part of this paper to deal with the geographical distribution of the pelagic Copepoda.

SYSTEMATIC ACCOUNT.

Family Calanidæ.

Genus *Calanus* Leach.

Calanus, Giesbrecht, 1892, p. 88 ; Giesbrecht and Schmeil, 1898, p. 13.

Calanus finmarchicus Gunnerus.

Calanus finmarchicus, Giesbrecht, 1892, p. 89, pl. vi, fig. 19, pl. vii, figs. 32, 33, pl. viii, figs. 3, 15, 20, 21, 31, 33 ; Sars, 1903, p. 9, pls. i–iii ; With, 1915, p. 11, figs. 1–5.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 male.

Distribution.—This species is very widely distributed throughout the Pacific and Atlantic Oceans. Ekman (1935, p. 407) sums up its range as extending from New Zealand as far south as 52°–53° S., south-east of Australia, Fiji, the Indo-Malayan region (Sulu Sea), Hong Kong, the Gulf of California, the West coast of South America, in the warm regions of the Atlantic, and extending as far northwards as the east coast of Greenland in 78° N., also in the Mediterranean Sea and the Black Sea ; in the Indian Ocean off South Africa and in the Red Sea. This reference to the Red Sea is taken from Farran's paper (1911), but in a letter to me Dr. Farran admits that the inclusion of the Red Sea in the range of distribution was an error of transcription.

Calanus finmarchicus has a wide vertical range, extending from the surface to a depth of some 2000 fathoms and, as is to be expected, an equally wide range of temperature, having been taken alive in temperatures ranging from 2·0° to 22·0° C., and in salinity ranging from 29·0°/₀₀ to 35·5°/₀₀ (*vide* Farran, 1911, and Ruud, 1929), and even 36·76°/₀₀ (*vide* Cleve, 1903).

The extreme rarity of this species in the Indian Ocean is a matter for considerable surprise. Further to the East Brady (1918) has recorded the species off Maria Island, Tasmania, and Farran (1929) has recorded its frequent occurrence from New Zealand southwards to Auckland and Campbell Islands, while in Melbourne Harbour it was common; but no examples were taken by the "Siboga" Expedition in the Malay Archipelago, nor by the Expedition to the Great Barrier Reef of Australia. To the west the species has been taken off the east side of Cape Colony at Port Shepstone at a depth of 900 m. (Cleve, 1904), and Brady has recorded its capture in Lat. 35° 9′ S., Long. 45° 30′ E., in or very near the northern portion of the West Wind drift; but no examples have ever been taken by the "Investigator" in the Laccadive Sea, the Bay of Bengal, or the Andaman Sea, nor is the species represented in any other collection from the northern part of the Indian Ocean or the Red Sea. It would thus appear probable that on extremely rare occasions individuals may be carried from the Atlantic Ocean round the Cape of Good Hope in the North Atlantic Intermediate water or the West Wind Drift, and then get caught up in the Sub-Polar Intermediate current, and so get carried northwards into the Arabian Sea.

Genus *Nannocalanus* Sars.

Nannocalanus, Sars, 1925, p. 9.

Nannocalanus minor (Claus). (Text-fig. 1, A, B.)

Calanus minor, Giesbrecht, 1892, p. 90, pl. vi, figs. 3, 16, 22, pl. vii, figs. 6, 22, pl. viii, figs. 1, 9, 19, 30; Wolfenden, 1906, p. 995, pl. xcvii, figs. 36–38.
Nannocalanus minor, Sars, 1925, p. 9; Sewell, 1929, p. 21, figs. 2 and 3.

Occurrence:

Sta. 56, South coast of Arabia, surface; 1 male.

Sta. 61 C, Northern area of Arabian Sea, surface; numerous examples: 1500–0 m.; 5 females, 2 males; 2000–0 m., 9 females, 1 male, 1 juv. The few examples in the nets from deep water were almost certainly captured in higher levels while the net was being hauled.

Descriptive Notes.—In a previous paper (Sewell, 1929, p. 20) I have recorded the occurrence in the same tow-netting of two forms of the female of this species, differing in the main only in size. These I termed f. *major* and f. *minor* respectively. The same two forms of the female are present in the collection from Sta. 61 C, and in addition there are a number of males that also appear to form two distinct size groups. The sizes of these groups are as follows:

Forma *major*:

Female; length ranging from	1·800–2·133 mm.,	average	1·974 mm.
Male; ,, ,,	1·666–1·800 ,,	,,	1·734 ,,

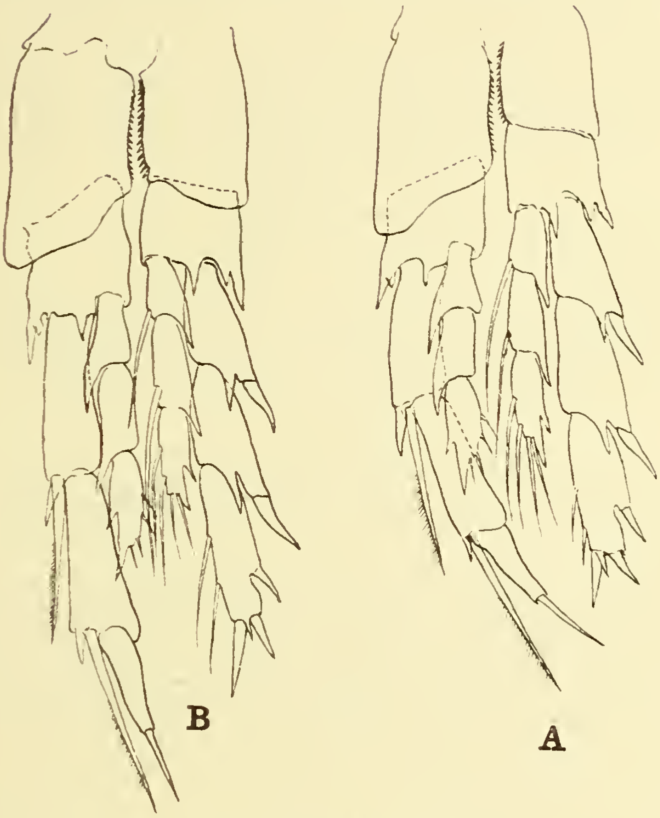
Forma *minor*:

Female; length ranging from	1·538–1·817 mm.,	average	1·726 mm.
Male; ,, ,,	1·533–1·666 ,,	,,	1·597 ,,

The proportional lengths of the various segments of the 1st antenna show slight differences in the two forms of the male, very similar to those seen in the two forms of the female, as is shown in the following table:

Segment	1–2.	3–5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
f. *minor*	125	75	25	22	20	20	25	28	33	42	44	47	47	50	53	56
f. *major*	126	77	27	25	21	21	27	33	37	43	46	47	48	48	49	50

20.	21.	22.	23.	24.	25.	
50	47	53	58	58	22	= 1000
46	46	50	56	56	21	= 1000



Text-fig. 1.—The 5th pair of legs of the male. A, *Nannocalanus minor* f. *minor*. B, *Nannocalanus minor* f. *major*.

The mouth-parts and swimming legs appear to be identical, and I am unable to discover any marked difference in the 5th pair of legs in the two forms, though certain small differences are noticeable (*cf.* Text-fig. 1, A and B).

Distribution.—This species has a wide distribution throughout the tropical and temperate regions of all three oceans, Pacific, Indian and Atlantic, and ranges from about 33° N. in the Atlantic to 50° S. in the Pacific Ocean. It also appears to have a considerable range of depth distribution ; it is usually a surface form, but Wilson (1932, p. 23) records it in the Woods Hole Region of the American coast from depths of 1500 fathoms (2743 metres).

Genus *Calanoides* Brady.

Calanoides patagoniensis Brady.

Calanoides patagoniensis, Brady, 1883, p. 75, pl. xxiii, figs. 1–10 ; Giesbrecht, 1892, p. 91, pl. vi, figs. 8, 10, 17, pl. viii, fig. 29 ; Giesbrecht and Schmeil, 1898, p. 16 ; Farran, 1929, p. 215.

Occurrence:

Sta. 45, South coast of Arabia, depth 38 m.; 1 juv.

Sta. 76, Gulf of Oman, 600 m. depth; 3 juv.; 1500 m. depth; 2 juv.

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 juv.; 2081–0 m., 2 juv.

Descriptive Notes.—Unfortunately none of these examples is fully mature, the most advanced being in the 5th Copepodid stage. The forehead is rounded without any trace of the projection that is present in *Calanoides brevicornis*; the posterior thoracic margin is somewhat acutely rounded and closely resembles the figure given by Giesbrecht (1892, pl. vi, fig. 17).

The marginal spine on the outer border of the 3rd segment of the exopod in swimming legs 2–4 divides this margin in the following proportions in the several legs:

2nd leg, 21 : 17.
3rd leg, 26 : 19.
4th leg, 27 : 18.

These proportions are much closer to those given by Giesbrecht and Schmeil (1898, p. 16) for *Calanus patagoniensis* (Brady) than to those for *C. brevicornis* Lubb.

Although these specimens are immature, I have little doubt that they belong to the above species.

Distribution.—Pacific Ocean, west coast of South America (Brady, Giesbrecht), Gulf of Oman and Arabian Sea (present records), and Atlantic Ocean, off Rio de Janeiro (Farran).

Tanaka (1937, p. 251) has recorded the occurrence of *Calanoides brevicornis* (Lubbock) from a depth of 500–250 meters off the coast of Heda, Sizuoka-ken. This example was an immature female, and in the rounded forehead, without any trace of a forward projection, and the rather pointed postero-lateral margins, closely resembles the present examples. It seems probable that this Japanese specimen was in reality an example of *Calanoides patagoniensis*.

Genus *Canthocalanus* A. Scott.

Canthocalanus pauper (Giesbrecht).

Calanus pauper, Giesbrecht, 1892, p. 91, pl. vi, fig. 4, and pl. viii, fig. 25; Wolfenden, 1906, p. 995, pl. xcvii, figs. 29–35.
Canthocalanus pauper, A. Scott, 1909, p. 9; Sewell, 1929, p. 25.

Occurrence:

Sta. 56, Southern Arabian Coast, surface; 3 specimens.

Sta. 61 C, Northern area of Arabian Sea, surface; numerous examples.

Distribution.—This species is widely distributed throughout the Pacific and Indian Oceans; it has also been recorded from the Mediterranean Sea (Thompson and A. Scott, 1903, p. 241), but up to the present time has not been obtained from the Atlantic Ocean. It would thus seem probable that this species has made its way into the Mediterranean Sea from the Red Sea through the Suez Canal, though Gurney (1927) only records it from Suez Bay and the southern end of the Canal.

Genus *Neocalanus* Sars.

Neocalanus gracilis (Dana).

Calanus gracilis, Giesbrecht, 1892, p. 90, pl. i, fig. 1, pl. vi, fig. 1, pl. vii, fig. 26, and pl. viii, figs. 2, 4, 6–8, 12, 16, 26 ; v. Breemen, 1908, p. 10, fig. 7.
Megacalanus gracilis, A. Scott, 1909, p. 12.
Neocalanus gracilis, Sars, 1925, p. 7.

OCCURRENCE.— Sta. 131 D, Southern area, Arabian Sea, 500–0 m., vertical haul ; 9 females, 1 juv.

DESCRIPTIVE NOTES.—The length of the immature form, which was in the 5th Copepodid stage, was 2·509 mm. The nine adult females exhibited a range of total length from 3·036 mm. to 3·309 mm., the average being 3·159 mm.

In this species, according to Giesbrecht and Schmeil (1898, p. 18) the external marginal spine divides the outer margin of the 3rd segment of the exopodite of the 2nd–4th swimming legs in the proportions 1 : 1, 4 : 3 and 4 : 3 : in the present specimens this spine divides the margin of this segment in all the legs in the following proportions :

Exopod 3 of P. 1, 20 : 15.
,, ,, P. 2, 34 : 35, or 1 : 1·03.
,, ,, P. 3, 53 : 35, or 4 : 2·64.
,, ,, P. 4, 65 : 33, or 4 : 2·03.
,, ,, P. 5, 45 : 25.

DISTRIBUTION.—This species has a wide range both horizontally and vertically. It has been taken in the Pacific Ocean in the San Diego region of the Californian coast (Esterly) and at several stations off the west coast of America and through the tropical region (Giesbrecht), off the Philippine Islands and in the Torres Straits (Giesbrecht), outside the Great Barrier Reef, and off New Zealand (Farran), and in the Malay Archipelago (A. Scott). In the Indian Ocean from Nankauri Harbour, Nicobar Islands (Sewell), off Minikoi (Thompson and A. Scott), the central and southern areas of the Arabian Sea (present records) and off the coasts of Natal and Cape Colony, but not south of the Agulhas Bank (Wolfenden). In the Atlantic Ocean it has been recorded from the Gulf of Guinea (T. Scott), the Canary Islands (Thompson), throughout the tropical and temperate regions (Giesbrecht, Farran), the Woods Hole region of the American coast (Wilson), to the south-east of Greenland (Jespersen), and as far north as 52° N. (Thompson), off the south-west of Ireland (Farran), in the Bay of Biscay (Farran), and in the Mediterranean Sea (Giesbrecht, Claus, Thompson, Cleve, Pesta).

Its vertical range extends from the surface, where it appears occasionally, down to 2688 m., but the depth limit appears usually to be in the region of 1000 m., and Farran states that most of the examples taken in the Bay of Biscay below this depth were dead.

Neocalanus robustior (Giesbrecht).

Calanus robustior, Giesbrecht, 1892, p. 91, pl. vii, figs. 15, 19, 25, 30, pl. viii, fig. 34 ; Wolfenden, 1906, p. 996, pl. xcvi, figs. 1–6.
Megacalanus robustior, A. Scott, 1909, p. 13.
Neocalanus robustior, Sars, 1925, p. 8.

OCCURRENCE.—Sta. 131 D, Southern area, Arabian Sea, 500–0 m., 2 females, 3 juv. ; 1500–0 m., 6 females.

Descriptive Notes.—♀. Total length ranges from 3·67 to 3·93 mm.

Distribution.—In the Pacific Ocean from the San Diego region of the Californian coast (Esterly) and from the west coast of America to 175° W. between the Equator and 20° N. (Giesbrecht), and in the Malay Archipelago (A. Scott). In the Indian Ocean from the Maldive and Laccadive Archipelagoes (Wolfenden), off Minikoi (Thompson and A. Scott), and the southern area of the Arabian Sea (present record). In the Atlantic Ocean throughout the temperate region, generally at considerable depths (Sars), and between Lats. 30° N. and 18° S. (Farran).

Rose (1929, p. 8) states that this species in the Atlantic is taken at least four times more frequently in deep water than at the surface, and exhibits a well-marked diurnal migration, rising towards the surface at night.

Genus *Undinula* A. Scott.

Undinula darwini (Lubbock).

Calanus darwini, Giesbrecht, 1892, p. 91, pl. vi, fig. 5, pl. vii, fig. 29, pl. viii, figs. 11, 37 ; Wolfenden, 1906, p. 994, pl. xcvii, fig. 40.
Undinula darwini, A. Scott, 1909, p. 17 ; Sewell, 1929, p. 42, figs. 11, 12.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 2000–0 m., 3 females, 2 juv. (probably caught while the net was being hauled).

Sta. 61 C, Northern area of Arabian Sea, surface, numerous examples.

Sta. 131 D, Southern area of Arabian Sea, 850–0 m., 1 female.

Descriptive Notes.—I have in a previous paper (Sewell, 1929) called attention to the variation that is found in the shape of the posterior process of the left side of the 5th thoracic segment ; among the present examples the common form is that which I have termed var. *intermedia*, though a few examples of the typical form are also present.

Remarks.—Two examples, both females from Sta. 61, present a very interesting abnormality. In both cases the two 1st antennæ were of approximately equal length, that on the right side measuring 2·05 and 2·08 mm. and that on the left 2·00 and 2·10 mm. in total length respectively ; but whereas the right antennule was normal and consisted of the full 25 segments, segments 8 and 9 being fused, the appendage of the left side in each specimen consisted of only 18 segments, segments 8 and 9 being fused. The proportional lengths of the segments in the two appendages are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
(1) Right .	59	77	30	28	30	28	28	54	32	32	39	44	45	45	45	47	49
Left .	54	74	34	34	36	39	41	88	52	52	66	66	76	79	76	68	68
(2) Right.	52	72	30	28	30	28	30	53	34	36	41	47	47	47	47	47	51
Left .	51	80	32	30	34	34	37	77	50	54	67	75	77	77	75	73	77

Segment	19.	20.	21.	22.	23.	24.	25.	
(1) Right .	49	39	41	44	44	39	29	= 1000.
Left .	—	—	—	—	—	—	—	= 1000.
(2) Right.	49	40	41	41	43	38	28	= 1000.
Left .	—	—	—	—	—	—	—	= 1000.

Gurney (1931, p. 43) has pointed out that in the case of *Eurytemora*, which possesses 24 free segments, 24 and 25 being fused, at the moult from the last naupliar stage to the 1st copepodid stage the segments of the 1st antenna increase from 3 to 9 as follows :

Nauplius.	1st Copepodid.
Segment 1 .	Segment 1.
,, 2 .	Segments 2 and 3.
,, 3 .	,, 4–9.

In subsequent moults these terminal six segments (representing segments 19–25) do not undergo further subdivision, the preceding 18 segments being derived from Segments 1 and 2 of the Nauplius or 1, 2 and 3 of the 1st Copepodid stage. A similar change is carried out in *Calanus finmarchicus*, as has been shown by Lebour (1916); in this species the 1st antenna in the naupliar stages is composed of 3 free segments, and in the moult to the 1st Copepodid stage this number increases to 10, of which the distal 6 presumably correspond to segments 19–25, segments 24 and 25 in this case being separate. It thus appears probable that the above abnormal condition is due to the loss in a nauplius stage of the terminal segment of the 1st antenna, either from injury or, possibly, as a mutation, with the resulting reduction in the total number of segments in the final stage to 18, but with a compensatory increase in the length of each individual segment. In one specimen the 3rd segment of the exopod of the 3rd leg on the left side was also absent, the ramus consisting of only 2 segments.

A number of specimens are infected with a parasite that appears to be *Blastodinium contortum* Chatton (*vide* Chatton, 1920, p. 175).

The breeding season appears to have been in full swing in the month of November at Sta. 61, for out of 100 adult females, selected at random, 35 were bearing spermatophores. It would seem that in this species there is no attempt on the part of the male to implant the spermatophore in the region of the vulva and, on the contrary, the selected site appears to be the dorsum of the thorax in the 3rd or 4th segments, as is indicated in the following Table :

Spermatophore on the	dorsum of thoracic segment iii . . .	14 cases.
,, ,,	junction of segments iii and iv . . .	4 ,,
,, ,,	dorsum of thoracic segment iv . . .	14 ,,
,, ,,	junction of segments iv and v . . .	1 case.
,, ,,	dorsum of thoracic segment v . . .	2 cases.

Distribution.—In the Pacific Ocean through the tropical region (Giesbrecht), off the Great Barrier Reef (Farran) and in the Malay Archipelago (A. Scott). In the Indian Ocean the species has been taken off the coast of Southern Burma (Sewell), in Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (Thompson and A. Scott, Pesta, present records), the Gulf of Aden and the Red Sea (A. Scott), the east coast of Africa (Thompson), the Agulhas Current (Cleve). In the Atlantic Ocean it has been reported from the tropical region (Lubbock) and from the North Atlantic (Brady).

Undinula vulgaris (Dana).

Calanus vulgaris, Giesbrecht, 1892, p. 92, pl. vi, fig. 11, pl. vii, figs. 2, 24, 27, 28, pl. viii, figs. 13, 17, 35; Wolfenden, 1906, p. 994, pl. xcvii, fig. 39.
Undinula vulgaris, A. Scott, 1909, p. 16; Sewell, 1929, p. 3, figs. 5–8.

Occurrence:

Sta. 61 C, northern area of Arabian Sea, surface, several examples.

Sta. 136, Maldive area, surface, juv. stage II, 15, stage III, 18.

Sta. 172, central area of Arabian Sea, 200–0 m., 1 male adult, 1 juv.; 850–0 m., 1 female (probably caught while the net was being hauled).

Distribution.—The temperate and tropical waters of all three oceans, especially between 20° N. and 20° S. of the Equator, but according to Wilson it may extend as far north as Lat. 41° in the Atlantic Ocean.

Family Megacalanidæ.

I propose the creation of a new Family to accommodate the three genera, *Megacalanus* Wolfenden, *Bathycalanus* Sars and *Bradycalanus* A. Scott. Hitherto these genera have been included in the Family Calanidæ, but they exhibit a very close relationship to each other, as is very clearly demonstrated by the confused synonymy lists of the several species (*vide* Farran, 1939), while differing in several features from all other members of the Calanidæ, and show a corresponding resemblance to the Centropagidæ. Most workers have regarded the genus *Calanus* as the most primitive of all the Calanoida, but Gurney (1931, p. 83) remarks: "The Calanidæ appear to be more nearly related to the Centropagidæ than to the other members of the Amphascandria, and one would suggest that a more natural arrangement would be to place the Centropagidæ in the position now occupied by the Calanidæ as the most primitive family."

Unfortunately the male of the genus *Bradycalanus* is still unknown, but tentatively one can give the following characters as features distinguishing the Megacalanidæ from the Calanidæ:

1. The presence of three marginal spines on the exopods of swimming legs 2–4.
2. The terminal spines on exopod 3 of the swimming legs are serrated on their outer margins. Although near the base of these spines the serrations are so closely set as to appear like a striated membrane, towards the tip of the spine the separate serrations become abundantly clear.
3. The right antenna of the male is modified into a grasping organ. I (1929, p. 27) called attention to the fact that in the males of *Megalanus princeps* Wolfenden (= *Megacalanus longicornis* (Sars)) this appendage in examples from the Bay of Bengal is modified to form a grasping organ, and Rose (1929) has shown that this is the condition in the male of *Bathycalanus rigidus* (Sars) (= *Bathycalanus princeps* (Brady)).
4. The 5th pair of legs is only slightly modified in the male. Both rami are three-jointed, and the 2nd segment of the exopod of the left leg bears a slightly modified seta on its inner border. This condition is known to be present in the males of *Megacalanus princeps* Wolfenden and in both *Bathycalanus princeps* (Brady) and *B. bradyi* (Wolfenden) (= *B. maximus* Wolfenden).

In addition to the presence of three spines on the outer margin of exopod 3 of the swimming legs 2–4, the Megacalanidæ present in the number of setæ on the lobes of the 2nd maxilla a feature that approximates to the condition found in the Centropagidæ. In the following table I have given the number of setæ on the various lobes of this appendage in various genera :

	Number of setæ on the lobes of Maxilla II.					
	Lobe 1.	2.	3.	4.	5.	6.
Calanidæ :						
Calanus, *Nannocalanus*, *Neocalanus*, *Undinula*	6	3	3	3	4	2 and 2 small
Calanoides .	6	3	3	3*	4*	1 and 3 small
Megacalanidæ :						
Megacalanus .	5 and 1 small	3	3	3*	3* and 1 small	1 and 3 small
Bathycalanus .	6	3	3	3	3 and 1 small	1 and 3 small
Bradycalanus .	6	3	3	3	2 and 1 small	1 and 3 small
Centropagidæ :						
Centropages .	5	3	3	3	3 and 1 small	1 and 2 small

* One of these is a definite spine.

Farran (1939) has recently reviewed the present position of the nomenclature and synonymy of the various species that are included in the genera *Megacalanus* Wolfenden and *Bathycalanus* Sars. There seem to be very few definite characters on which one can rely for the separation of these two genera. Rose (1929, p. 13) in his key to the genera and species relies, among other characters, on the prehensile character of the right 1st antenna in the male, the absence of a retroverted spine on the 2nd basal segment of the 1st leg and the ribbon-like character of the setæ on the terminal segments of the 2nd maxilla, as serving to discriminate *Bathycalanus* from *Megacalanus*, but the first of these is, in my opinion, not reliable. Among the species of *Bathycalanus* Wolfenden (1911) has described the male of *Bathycalanus bradyi* (Wolfenden), but he made no mention of the prehensile nature or otherwise of the 1st antenna ; Rose (1929, p. 9) has, however, shown that in the male of *B. rigidus* Sars this appendage on the right side is definitely prehensile. On the other hand, the males of *Megacalanus princeps* Wolfenden have been described by Wolfenden, Sars and others, all of whom state that the antennules of the male are similar to those of the female and are thus non-prehensile ; yet every male examined by me (1929, p. 27) in the "Investigator" collections from Indian Seas showed a clearly prehensile right antenna, and Vervoort (1946) has confirmed this in males taken by the "Snellius" Expedition in the Dutch East Indies. The presence of a retroverted spine on the 2nd basal segment of the 1st leg is merely a specific character of *Megacalanus princeps* Wolfenden ; but even so is not always reliable, for in the "John Murray" collections there

is a specimen that agrees in every other respect with *Megacalanus princeps* Wolfenden but in which this spine is conspicuous by its absence. The setæ arising from the terminal portion of the 2nd maxilla are in the genus *Bathycalanus* curled at the end, and are clad in a double row of dense, closely set spinules, giving a ribbon-like appearance to these structures ; the corresponding setæ in the genus *Megacalanus* are armed with separate spinules and are not curled at the ends ; in *Megacalanus sarsi* (Farran), *M. gigas* sp. nov. and *Bradycalanus typicus* A. Scott, however, these setæ are scythe-shaped, and are clothed in two rows of densely set spinules, that exactly recall the arrangement in *Bathycalanus.*

One character to which sufficient attention has not been paid in the past is the number of setæ that are present on the various lobes of the 1st maxilla ; in the following table I have given the arrangement in different species of the two genera :

	Genus *Megacalanus.*		Genus *Bradycalanus.*			Genus *Bathycalanus.*		
	M. princeps Wolfenden, var. *inermis*, nov.	*M. princeps* Wolfenden.	*B. gigas* sp. nov.	*B. sarsi* (Farran).	*Bradycalanus typicus* A. Scott.	*B. richardi* Sars and *B. bradyi* Wolfenden.	*B. princeps* (Brady).	*B. medius* (Wolfenden).
Le. 1 . . .	9	9	9	9	9	9	9	7
Le. 2 . . .	1	1	0 or 1	1	1	1	1	0
Re. . . .	11	11	10 or 11	11	9	11	11	11
Li. 1 . . .	14	12	15	12	13	11	10	10
Li. 2 . . .	5	4	5*	3	2	0	0	0
Li. 3 . . .	4	5	2	3	?	2	2	2
B. 2 . . .	4	4	4	3	4	3	2	2
Ri. 1 . . .	3	3	2	2	2	2	2	2 (?1)
Ri. 2 . . .	4	4	1	1	1	1 or 2	1	1 (?2)
Ri. 3 . . .	7	6 or 7	6*	5	5	6 or 7	4 or 5*	5*

* One seta quite small.

It seems clear from the above that the genus *Bathycalanus* is distinguished by the total absence of any setæ arising from the 2nd inner lobe, whereas in the genus *Megacalanus* the number ranges from 3 to 5. A comparison of the number of setæ on the different parts of the appendage in different species of *Megacalanus* shows that *M. princeps* Wolfenden can be distinguished from other members of the same genus by the presence of four setæ on the 2nd segment of the endopod ; in *Bradycalanus gigas* sp. nov. and *M. sarsi* (Farran) there is only a single one, and the same is true of *Bradycalanus typicus* A. Scott, if we can rely on A. Scott's figure (1909, pl. i, fig. 5).

Attention has already been called to the minute sense organs, " maculæ cribrosæ," that occur on the appendages of this species (*vide* With, 1915, and Sewell, 1929). In the present specimens I have again carefully examined a specimen of *Megacalanus princeps* Wolfenden, and in the Table below I have given a complete list of these, and also of the similar sense organs in *Bathycalanus bradyi.* Up to the present time I have, however, completely failed to discover any such sense organs in either *Bradycalanus gigas* sp. nov.,

or in a young example of what I take to be *Bradycalanus typicus* A. Scott in the last copepodid stage.

	Megacalanus princeps.	*Bathycalanus bradyi.*
Antenna I, segment 2, upper surface	3	..
Antenna II. basal 2, upper surface	1	..
Endopod i, about $\frac{1}{5}$ from distal end	1	1
5th segment of exopod	1	1
Mandible, basal 1, near base of teeth	1	..
basal 2. near origin of exopod	1	1
1st Maxilla, basal 1, near base of Le 1,	1	1
lateral margin of exopod near base	1	..
2nd Maxilla, basal 1, anterior surface	1	1
lobe 4	..	1
Maxilliped, basal 2, anterior surface	1	1
endopod, segment 4	1	..
1st leg, basal 2, near origin of endopod	1	1
exopod 2, near base of spine	1	..
endopod 2, middle of segment	1	..
2nd leg, basal 1, near outer margin	1	..
basal 2, near origin of endopod	1	1
exopod 1, near base of spine	1	..
exopod 2, near base of spine	1	1
exopod 3, near base of 1st spine	1	1
near base of 2nd spine	1	1
endopod 2, middle of segment	..	1
3rd leg, basal 1	1	..
basal 2	1	..
exopod 1, near base of spine	1	1
exopod 2, near base of spine	1	1
exopod 3, near base of 1st spine	1	1
near base of 2nd spine	1	1
endopod 2	1	1
4th leg, basal 1	1	1
basal 2	1	1
exopod 1, near base of spine	1	1
exopod 2, near base of spine	1	1
exopod 3, near base of 1st spine	1	1
near base of 2nd spine	1	1
endopod 2	1	1
5th leg, basal 1	..	1
basal 2	1	1
exopod 1, near base of spine	1	1
exopod 2, near base of spine	1	1
exopod 3, near base of 1st spine	1	..
endopod 2	..	1
endopod 3	[illegible]	[illegible]

In addition to the "maculæ cribrosæ" which have been recorded from the various segments of the appendages there are several on the somites of the body. In *Megacalanus princeps* (Text-fig. 2, A) I have been able to detect four such organs on the ventro-lateral region of the Cephalon, a pair set obliquely from above downwards and backwards opposite the point of origin of the 2nd antenna, and a second pair, also set obliquely, opposite the point of origin of the 1st maxilla. On thoracic segment 1 in the ventro-lateral region near the posterior margin is a single "macula." On segments 2 and 3 in the ventro-lateral region there is a pair, set obliquely from above forwards and downwards, the anterior "macula" situated not far behind the overlapping border of the anterior segment and the posterior close to the posterior margin. Segment 4 possesses a single "macula" near the posterior margin. Similarly on the segments of the abdomen there seems to be a "macula" on the three anterior segments; thus in the female there is a pair on the lateral aspect of the genital segment (segments 1 and 2), the posterior being at a slightly higher level than the anterior, and on the 2nd free segment (segment 3) there is a single "macula" near the posterior margin. I have been unable to detect a macula on segment 4, but there is one in the dorso-lateral region, just posterior to the anal flap on segment 5; finally there is a single "macula" on the outer margin of the furcal ramus just proximal to the origin of the outermost furcal seta. The approximate positions of these body "maculæ" are shown in Text-fig. 2, A, but it must be noted that the size, as shown, is much too large.

Key to the Genera and Species of Megacalanidæ.

1. The rostral filaments are moderately slender and tapering; the exopod of the 1st leg bears 1, 1 and 2 external marginal setæ on the three segments; the 2nd inner lobe of the 1st maxilla bears from 2 to 5 setæ:

   A. The 1st antenna is very long, nearly twice the length of the body, and over-reaches the furcal rami by about 8 segments; the 2nd segment of the endopod of the 1st maxilla bears 4 setæ; the setæ of the terminal part of the 2nd maxilla are armed with moderately spaced spinules; circular or oval "maculæ cribrosæ" are present . . . . *Megacalanus.*
   - *a.* There is a hook on basal 2 of the 1st swimming leg . . . *Megacalanus princeps* Wolf.
   - *b.* There is no hook on this segment . . . . *M. princeps* var. *inermis* nov.

   B. The 2nd segment of the endopod of the 1st maxilla bears only 1 seta; the setæ of the terminal part of the 2nd maxilla are scythe-like and are densely ciliated; "maculæ cribrosæ" appear to be absent . . . . *Bradycalanus.*
   - *a.* The 1st antenna is of moderate length and over-reaches the furcal rami by the last 4 or 5 segments:
     1. The posterior thoracic margin is rounded; total length, 11–12 mm. . *B. sarsi* (Farran).
     2. The posterior thoracic margin is produced in distinct points; total length 9 mm. *B. typicus* A. Scott.
   - *b.* The 1st antenna is short, barely exceeding the length of the body; posterior thoracic margin is rounded; total length 14·9 mm. . . . . *B. gigas* sp. nov.

II. The rostral filaments are stout and sausage-like; the exopod of the 1st leg bears 0, 0 and 2 external marginal setæ on the segments; the 2nd inner lobe of the 1st maxilla is devoid of setæ; the setæ on the terminal part of the 2nd maxilla are ribbon-like and are densely clad with spinules; sensory organs resembling "maculæ cribrosæ" are present, but are arranged in a clump and not in an oval or ring *Bathycalanus.*

   A. A pair of small spines on the forehead:
   - *a.* Exopod of the 1st leg 2-jointed . . . . *B. bradyi* Wolfenden (= *B. maximus* Wolf.).
   - *b.* Exopod of the 1st leg 3-jointed . . . . *B. richardi* Sars.

   B. A longitudinal crest on the forehead . . . . *B. princeps* (Brady) (= *B. rigidus* Sars and *B. medius* (Wolf.)).

Genus *Megacalanus* Wolfenden.

Megacalanus, Wolfenden, 1904, p. 112 ; 1905, p. 1.
Macrocalanus, Sars, 1905*a*, p. 7 ; 1907, p. 3.
Megacalanus, Sars, 1925, p. 14 ; Rose, 1929, p. 11 ; Farran, 1939, p. 355.

At the present time this genus includes only a single species, *Megacalanus princeps* Wolfenden. This species is usually characterized by the presence on the 2nd basal segment of the 1st leg of a retroverted spine ; Wolfenden (1905) in his original definition of the genus makes no mention of this spine, and as he included in the genus a second species, *Megacalanus princeps* (Brady), later transferred to the genus *Bathycalanus* under the name *B. bradyi* (Wolf.), in which this spine is absent, he apparently did not consider it a generic character. A. Scott (1909, p. 12), however, considered this hook or spine to be a characteristic feature of the genus, for he writes, " I include under the genus *Megacalanus* only those Calanoids that have the anterior surface of the second joint of the basiopodite of the first pair of feet furnished with a strong hook as originally defined by Wolfenden." He thus included in this genus two other species, *Calanus gracilis* (Dana) and *C. robustior* (Giesbrecht) Sars (1925), removed these two species, and placed them together with *Calanus tenuicornis* Dana in a new genus *Neocalanus*. It thus seems clear that this spine must be regarded as an example of convergence and is not a generic character ; it seems doubtful whether it can even be regarded as a specific character, since in the John Murray Collection there is a specimen in which it is absent.

Megacalanus princeps Wolfenden. (Text-fig. 2, A–G.)

Megacalanus princeps (later emended to *M. bradyi*) Wolfenden, 1905*a*, p. 1, pl. i, figs. 1–6.
Megacalanus princeps, Wolfenden, 1911, p. 196, pl. xxii, figs. 1–11, text-fig. 1, *a*, *b* ; With, 1915, p. 41, pl. i, figs. 3, *a–i*, text-fig. 8, *a–d*.
Megacalanus longicornis, Sars, 1925, p. 11, pls. i, ii ; Sewell, 1929, p. 27.

Occurrence :

Sta. 96, Central area of Arabian Sea, 390–635 m., 1 juv.
Sta. 98, Central area of Arabian Sea, 2800–0 m., 1 female.
Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female ; 1500–0 m., 2 females, 5 juv. ; 2500–0 m., 1 female.
Sta. 172, Central area of Arabian Sea, 850–0 m., 2 juv. ; 2091–0 m., 2 juv.

Remarks.—The majority of these specimens appear to agree exactly with the previous accounts, but a single specimen showed an interesting abnormality.

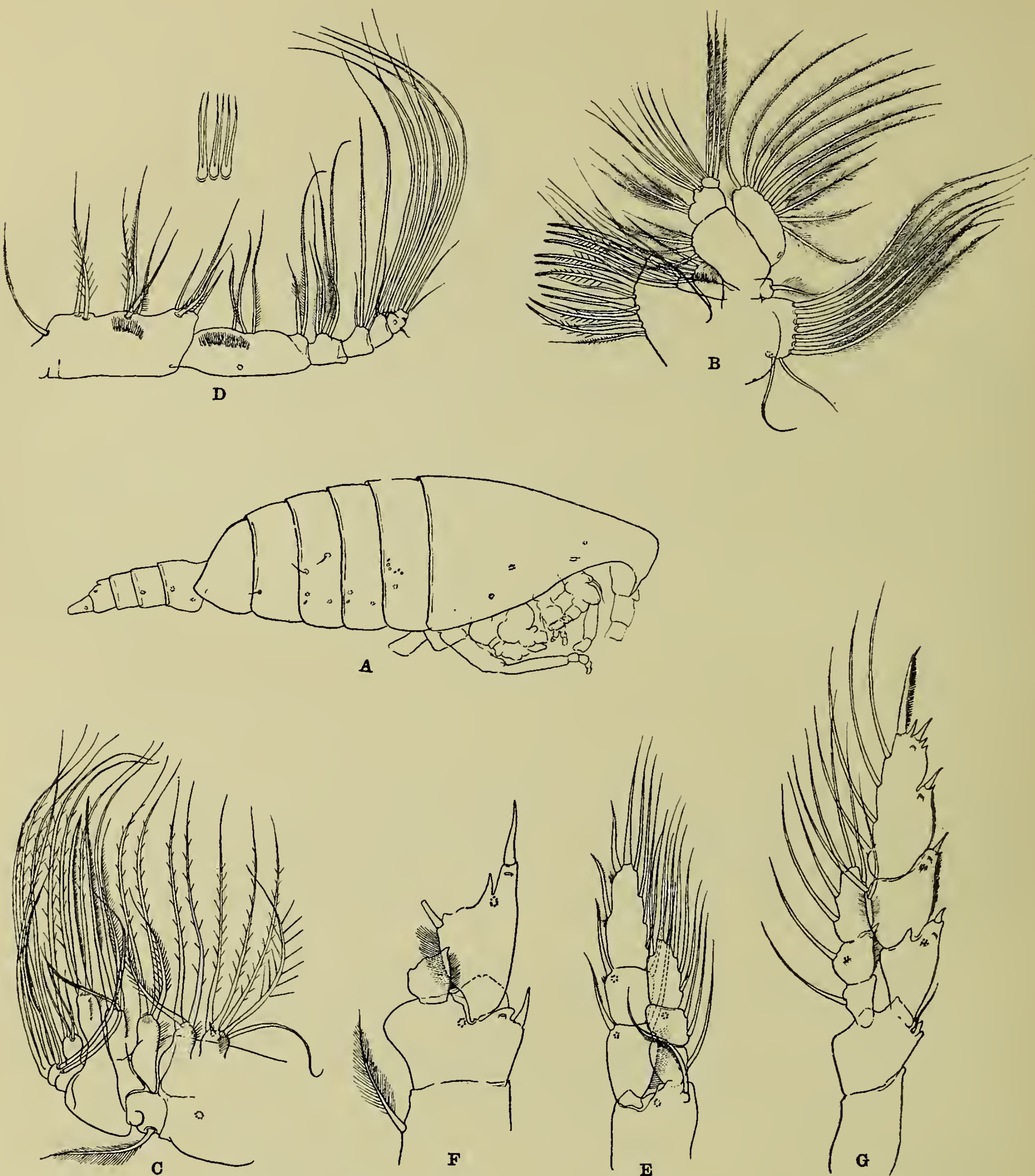
Abnormality : *inermis* nov.

Occurrence.—Sta. 98, Central area, Arabian Sea, 2800–0 m., 1 female.

♀. Total length 8·73 mm.

The proportional lengths of cephalothorax and abdomen are as 75 to 25.

The posterior thoracic margin on each side is produced backwards and ends in a bluntly rounded prominence, that on the left side being more acutely rounded than on the right. The abdomen is composed of the normal four segments, having the following proportional lengths—41, 17, 13 and 12, the furcal rami being 17.



TEXT-FIG. 2.—*Megacalanus princeps* Wolfenden, var. *inermis* nov., ♀. A, Lateral view. B, 1st maxilla. C, 2nd maxilla. D, Maxilliped. E, 1st leg. F, Basal part of 2nd leg. G, 5th leg.

The 1st antenna is unfortunately broken, but the proximal 17 segments have the following proportional lengths :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.
33	40	19	23	26	27	27	51	35	36	41	43	43	48	48	50

Segments 8 and 9 are fused and segments 13 and 14 are finely serrated along the distal half of the posterior margin, a character that was pointed out by Wolfenden, who stated

that this armature was on segments 12 and 13, but presumably he counted the fused segments 8 and 9 as one.

The mouth-parts agree with those of a typical example. With (1915, p. 42) has called attention to the hairs (spinules) on the 2nd basal segment (according to his nomenclature B III) of the maxilliped, which he describes as being "bifurcate or divided into three branches"; in the present specimen there was a line of simple spines along the base of this patch, and the remainder of the spinules were all bifurcate.

The 1st leg (Text-fig. 2, E) differs from that of the typical form by the absence of the characteristic spine on the anterior aspect of the 2nd basal segment. The other legs are similar to those in the typical form.

Distribution.—South and West of Iceland, 1000–1800 metres (With), North Atlantic Ocean, surface to 5700 metres (Sars), Biscayan region of the North Atlantic Ocean, 457–1892 metres (Farran), near Cape Verde Islands, 3000 metres (Wolfenden), Equatorial Atlantic Ocean, 800–3000 metres (Wolfenden), South Atlantic Ocean, 2450 metres (Wolfenden), South Indian Ocean—near the ice-edge—2450 metres (Wolfenden), Arabian Sea, 600–2800 metres (present records), Bay of Bengal, 732 metres (Sewell) and the Malay Archipelago, 1500 metres (A. Scott). With records it from 10 stations off Iceland, and Sars obtained it from no less than 43 stations in the central region of the North Atlantic; judging from the depth distribution the species must be an inhabitant of the North Atlantic Intermediate water, and it seems probable that it has followed the general trend of movement of this great water mass and has been carried southward into the South Atlantic Ocean and then eastward round the Cape of Good Hope into the Indian Ocean, where, passing into either the sub-polar Intermediate current or the Antarctic bottom drift, it has been carried northwards to the Arabian Sea and the Bay of Bengal.

Genus *Bradycalanus* A. Scott.

Bradycalanus, A. Scott, 1909, p. 14.

A. Scott (*loc. cit.*) separates this genus from the closely related genus *Megacalanus* Wolfenden by the densely plumose character of the spines of the terminal part of the 2nd maxilla (1st maxilliped) and the absence of the hook on basal 2 of the 1st swimming leg, and from *Bathycalanus* Sars by the possession of three segments in the exopod of the 1st leg. Neither of these characters is reliable. Nevertheless, Farran (1939, p. 359) remarks, "I have also assumed the generic distinctness of *Megacalanus and Bradycalanus*"; I agree with Farran, and it seems to me that there are certain, though perhaps slight, differences of character that are reliable:

1. The 2nd segment of the endopod of the 1st maxilla bears only 1 seta instead of 4 as in *Megacalanus*.
2. The spines on the terminal part of the 2nd maxilla are scythe-like and are densely plumose, instead of being armed with moderately widely-spaced spinules as in *Megacalanus* or ribbon-like as in *Bathycalanus*.
3. The exopod of the 1st leg is composed of three segments, the 1st and 2nd bearing one seta each on the outer margin and the 3rd 2 marginal setæ and an end-spine, as in *Megacalanus*; whereas in *Bathycalanus* the marginal setæ on segments 1 and 2 are absent.

4. The rostral filaments are tapering as in *Megacalanus*, and not sausage or club-shaped as in *Bathycalanus*.

5. Cutaneous pores of the " maculæ cribrosæ " type appear to be absent.

If the above definition be accepted, this will necessitate the transference of the species *Megacalanus sarsi* Farran (*Megacalanus princeps* Sars (1925)) to the genus *Bradycalanus*.

Bradycalanus gigas sp. nov. Text-fig. 3, A, D.)

Occurrence.—Sta. 120, Zanzibar area, 2926 m., 1 female.

Descriptive Notes.—♀. Total length, 14·9 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 : 24.

The head and 1st thoracic segment are separate, as also are thoracic segments 4 and 5. The rostral filaments are short and stout, and are directed backwards; they taper to a fine point, and immediately above their base is a small median papilla from which arise two minute sensory hairs. The forehead is rounded, the whole cephalothorax is robust and the posterior thoracic margins are rounded. The abdomen consists of the usual four segments, that have with the furcal rami the following proportional lengths :

Abdominal segment 1–2.	3.	4.	5.	Furca.
48	19	11	6	16 = 100.

The genital segment is symmetrical and is somewhat swollen, anteriorly, on the ventral aspect.

The 2nd furcal seta is unfortunately broken off on each side, but it is much stouter than the other furcal setæ.

The 1st antennæ are almost exactly equal in length to the whole body ; they consist of 25 segments having the following proportional lengths :

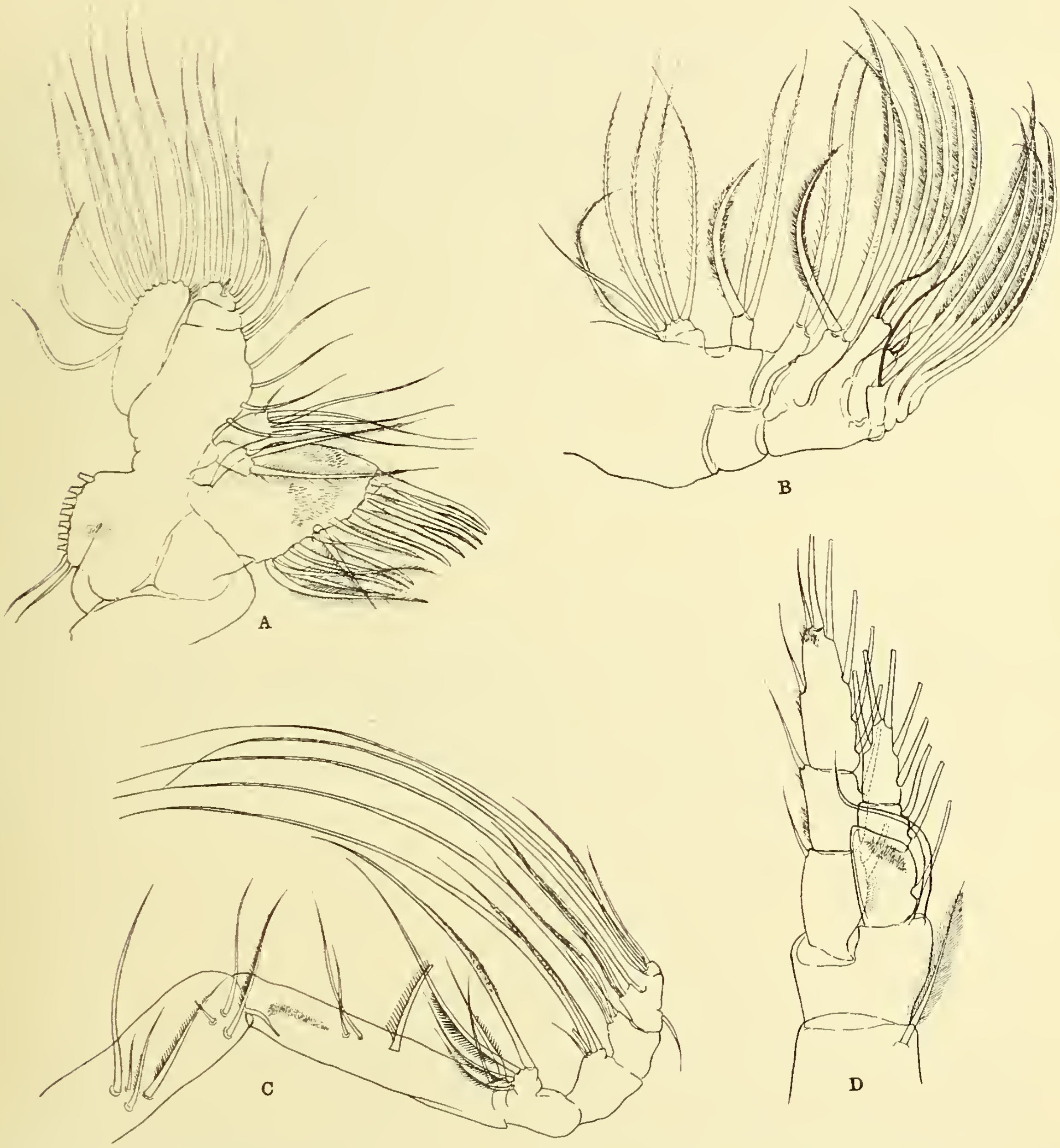
Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
61	58	24	25	26	26	26	25	26	33	35	41	51	53	59	59	60	59

19.	20.	21.	22.	23.	24.	25.
59	41	39	37	33	17	27 = 1000

The 24th segment is relatively short, and both it and the 23rd segment bear a very stout and strong plumose filament, as in *Bradycalanus sarsi* (Farran).

The 1st maxilla (Text-fig. 3, A) differs from that of *Megacalanus princeps* Wolfenden, and resembles *M. sarsi* Farran in the reduced numbers of setæ arising from the distal segments of the endopod. The 1st inner lobe bears in all 15 spine-like setæ, of which those arising from near the base are fringed with hairs, while the more distal six are stout and strongly chitinised ; the anterior aspect of this lobe is clothed with short hairs. The 2nd lobe is long and curved and bears one short and four long setæ. The 3rd lobe is short and bears only two setæ. The 2nd basal segment and the 1st segment of the endopod are fused ; four setæ arise from the basal part and two from the distal inner angle of the portion that corresponds to the 1st segment of the endopod ; the 2nd segment of the endopod bears only a single seta ; the 3rd segment bears five setæ, and a short, curved, spine-like process arises from the anterior aspect of the segment. The exopod bears eight long setæ

and a 9th appears to have been broken off: and two shorter ones spring from the margin proximally, making 11 in all. The 1st outer lobe bears seven long setæ and two short ones proximally. The 2nd outer lobe is apparently without a seta.



TEXT-FIG. 3.—*Bradycalanus gigas* sp. nov., ♀. A, 1st maxilla. B, 2nd maxilla. C, Maxilliped. D, 1st leg.

The 2nd maxilla (Text-fig. 3, B) is well developed. It agrees closely with the corresponding appendage of *M. sarsi* Farran (*vide* Sars, 1925, pl. iii, fig. 8). The 1st lobe bears 6 setæ: the 2nd 3, of which one is stout and claw like; the 3rd bears only 2 setæ, and the 4th 3, one of which and the other two scythe-like and closely fringed with hairs is claw-like; the 5th lobe bears 3 setæ, one being small and the other two scythe-like; the next lobe

bears one scythe-like seta and a very small plain seta. From the endopodal portion of the limb arise five scythe-like setæ and one moderately small plain seta. All the scythe-like setæ are fringed with a very closely set row of fine hair-like spinules along the inner margin, as in *Bradycalanus typicus* A. Scott.

The maxilliped (Text-fig. 3, C) is of the usual Calanoid type and the setæ arising from the terminal segments are long and slender.

The 1st swimming leg (Text-fig. 3, D) closely resembles that of the form described by Sars under the name *Macrocalanus princeps* (Brady) (= *M. sarsi* Farran). The 1st basal segment bears a seta at its distal inner angle ; the 2nd basal carries the usual S-shape seta at the distal inner angle and this arises from a small boss, but there is no hook-like spine as in *Megacalanus princeps* Wolfenden. The exopod consists of three clearly separated segments ; of these the 1st and 2nd each bear an external marginal seta-like spine and an inner seta, the 3rd segment bears two marginal spines and an end-spine as well as four inner setæ ; the proximal seta divides the outer margin into proximal and distal regions that have the relative lengths of 75 to 55. The endopod also consists of three segments, of which the 1st is by far the longest and the 2nd comparatively short ; they have the proportional lengths of 98 : 35 : 72. Sars, in his figure of *Megacalanus princeps* (Brady), shows them as being nearly equal.

The 2nd–4th swimming legs all bear three marginal spines on the 3rd segment of the exopod.

The 5th swimming leg closely resembles that of *Bradycalanus sarsi* (Farran), as figured by Sars (1925, pl. iii, fig. 12).

Remarks.—While closely resembling the form described by Sars under the name *Megacalanus princeps* (Brady), the present species differs from it in certain particulars, of which the most important are (1) the comparative shortness of the 1st antenna, which in the present species is only equal to the length of the whole body instead of exceeding this by one quarter of their length, and (2) the length of the 1st segment of the endopod of the 1st swimming leg, which is far longer than in Sars' form.

Bradycalanus sp., juv.

? *Bradycalanus typicus*, A. Scott, 1909, p. 14, pl. i, figs. 1–11.

Occurrence.—Sta. 186, Gulf of Aden, 600–0 m., 1 juv. (Stage V).

Descriptive Notes.—Copepodid Stage V. Total length, 7·2 mm.

The head is rounded without any trace of a frontal crest, and the rostral filaments are moderately stout and are tapered and recurved. The posterior thoracic margins are produced backwards and are somewhat sharply rounded, and at the tip are produced into sharp points, exactly as A. Scott has described in *Bradycalanus typicus*, and as With (1915) p. 41, fig. 8, *d*) has figured for a young example of *Megacalanus princeps* Wolfenden.

The abdomen is composed of 4 segments that have the following proportional lengths:

Segment 1.	2.	3.	4–5.	Furca.
17	30	15	19	19 = 100

The 1st antenna must have over-reached the tip of the furcal ramus by about the last

four segments. Segment 25 is unfortunately missing, but the other segments have the following proportional lengths :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14	15.	16.	17.	18.	19.
56	60	22	22	25	23	24	42	36	40	46	54	56	60	60	58	48	44

20.	21.	22.	23.	24.	25.	
32	32	44	44	28	(44)=	1000

Segments 7 and 8 are fused. Segments 3 to 7 inclusive bear a transverse row of setæ on their posterior aspects. Segment 24 is considerably shorter than segment 23, as in *Bradycalanus sarsi* (Farran) ; and segments 23 and 24 each bear a long stout and plumose seta.

In the 2nd antenna the endopod and exopod are of equal length.

The biting ramus of the mandible is powerful and is armed with 5 strong teeth, decreasing in size, 2 small pointed spines and a posterior, stout, spine-like process.

In the 1st maxilla the various parts bear the following setæ :

Le. 1	..	7 large and 2 small on one side and 5 large and 2 small on the other.
Le. 2	..	1
Re.	..	10
Li. 1	..	14
Li. 2	..	5
Li. 3	..	3
B. 2	..	4
Ri. 1	..	2
Ri. 2	..	1 large and 1 small.
Ri. 3	..	5 large and 1 small.

In the 2nd maxilla the number of setæ on the various lobes are as follows : on segment 1, on lobes 1 to 3, 6, 3 and 3 ; on segment 2 (lobe 4) 3, on endopod 1 (lobe 5) 3, one being distinctly stouter than the other two, on endopod 2 (lobe 6) 4, three being quite small, and on the terminal segments, 7, one quite small ; a plumose seta arises from the posterior margin of segment basal 2.

The maxilliped is of the usual shape and the number of setæ on the various segments is as follows : basal 1 bears 3, 4 and 4, basal 2, 3 and 2, endopod 1 and 2, 3 each, endopod 3 and 4, 2 each and endopod 5, 3. Endopod 4 also bears an outer seta.

In the 1st leg the 2nd basal bears an inner seta but there is no spine as in *M. princeps*. The segments of the exopod bear 1, 1 and 2 external setæ. The 2nd to 4th legs are as in the adult, each ramus being composed of three segments. The 5th leg is not yet fully developed, the rami possessing only two segments, segments 2 and 3 not yet having become differentiated. It is clear, however, that the terminal segment of the exopod will bear only 2 marginal spines in the adult stage.

Remarks.—In the shape of the posterior thoracic margins this specimen closely resembles *Bradycalanus typicus* A. Scott ; the total length of the specimen, namely 7·2 mm., agrees with what one would expect in the 5th Copepodid stage of this species, that has a total length in the adult stage of about 9 mm., as the growth factor would then be in the neighbourhood of 1·250 ; whereas with an adult measuring from 11 to 12 mm. as in *B. sarsi*

(Farran), the growth factor would have to be as high as 1·529–1·667. Still less is this example likely to be an immature stage of *B. gigas* sp. nov., which has a length of 14·9 mm.

Genus *Bathycalanus* Sars.

Bathycalanus, Sars, 1905*a*, p. 7, and 1925, p. 16.

At the present time this genus comprises three species, the correct names of which, according to Farran (1939), are *Bathycalanus richardi* Sars, *B. bradyi* (Wolfenden) and *B. princeps* (Brady). With (1915, p. 39) has already called attention to the presence in *Bathycalanus princeps* (Brady) on some of the swimming legs of sensory organs, similar to those present in the species *Megacalanus princeps* Wolfenden and named by him " maculæ cribrosæ." As With has pointed out, in *Bathycalanus princeps* these are less regular in number as well as in arrangement. With, however, did not in all probability detect the full series, and a careful study of a specimen of *Bathycalanus bradyi* (Wolfenden) has revealed several others. The full list of these organs that I have so far been able to detect is given above on p. 23 ; it must be noted, however, that in this genus these sense-organs do not exhibit the ring-form that is so characteristic of them in *Megacalanus*, but the small pores are arranged in clumps. Where present these clumps occupy the same, or very nearly the same, position on the various appendages and the body segments as in *Megacalanus princeps*.

Bathycalanus bradyi (Wolfenden). (Text-fig. 4, A–C.)

Megacalanus bradyi, Wolfenden, 1905, p. 3, pl. i, figs. 7–9.
Bathycalanus maximus, Wolfenden, 1911, p. 189, pl. xxiii, figs. 1–7, and text-fig. 2*a*, *b*.

(For the full synonymy, *vide* Farran, 1939.)

Occurrence.—Sta. 76, Gulf of Oman, 2500–0 m., 1 female.

Descriptive Notes.—♀. Total length, 11·93 mm.

Wolfenden gives the lengths of his specimens as ranging from 10·9 to 12·0 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 to 24. The proportional lengths of the various segments of the body are as follows :

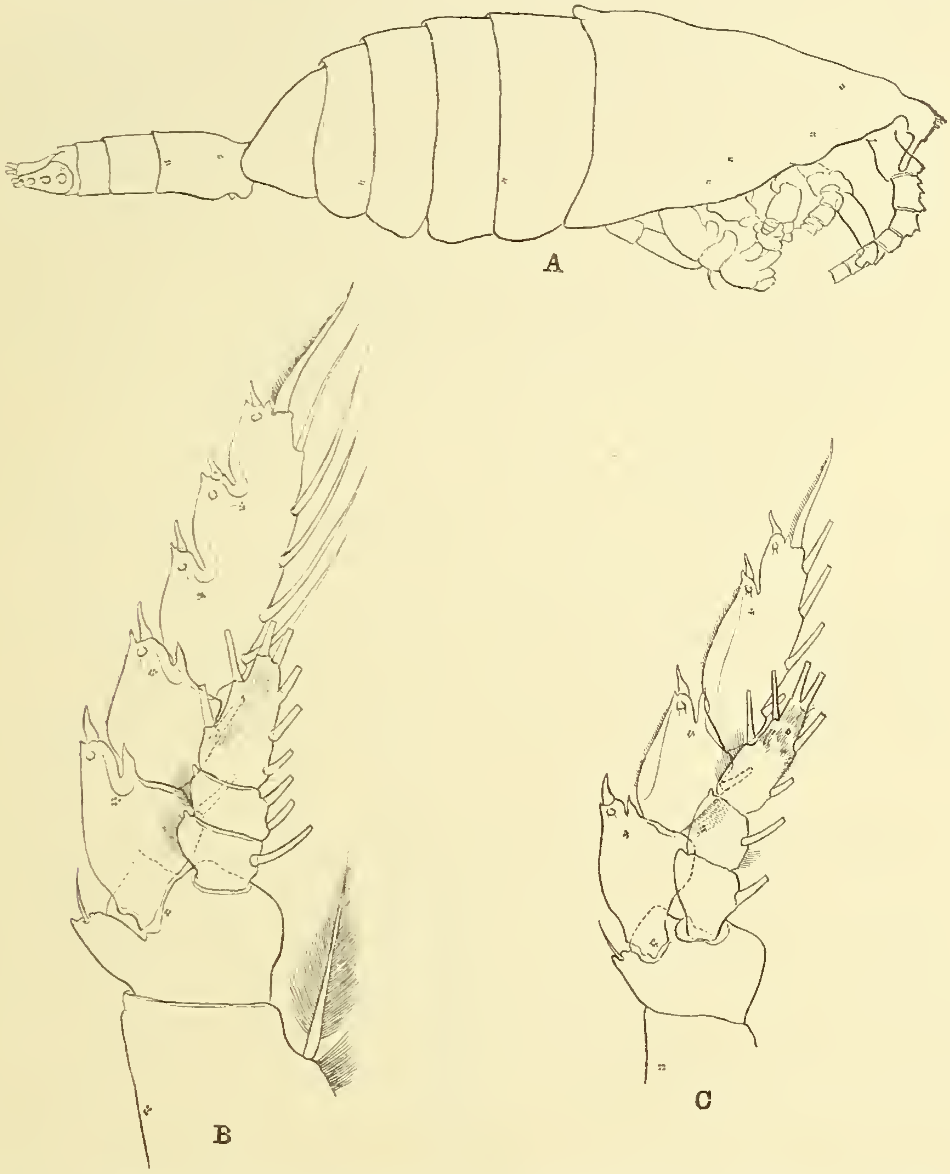
Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.	
360	107	73	66	53	79	100	69	45	13	35	= 1000.

The head (Text-fig. 4, A) is markedly tapered anteriorly and at the extreme anterior end is produced in a pair of short horns, immediately below which is a pair of small sensory hairs. On the posterior margin in the mid-dorsal line the cephalon is produced in a bluntly rounded eminence. The rostral processes are sausage-like. The five thoracic segments are separate and the posterior thoracic margin is rounded. Wolfenden (1911, p. 198) states that the two last thoracic segments are fused, but in the present example they are clearly separate, at any rate in the mid-dorsal line.

The abdomen is composed of four separate segments, of which the posterior or anal segment is very short.

I have been able to detect several " maculæ cribrosæ " on the body. On the cephalon in the dorso-lateral region there is one situated between the points of origin of the 1st and 2nd antennæ and a second is situated near the lateral border opposite the origin of the

2nd antenna. Opposite the origin of the 1st maxilla are two more situated near the lateral margin, the anterior being at a rather higher level than the posterior. A single macula is seen in the ventro-lateral region of the 1st and 3rd thoracic segments close to the posterior margin. The genital segment of the abdomen possesses a pair of maculæ, the anterior



Text-fig. 4.—*Bathycalanus bradyi* (Wolfenden), ♀. A, Lateral view. B, 4th leg. C, 5th leg.

in line with the genital orifice and the posterior near the hinder margin. A single macula has also been seen on the furcal ramus just above the articulation of the outermost seta.

Unfortunately both 1st antennæ are broken off.

The mouth-parts agree with the descriptions and figures given by Wolfenden (1911).

In the 1st swimming leg the exopod is clearly divided into three segments, of which the 1st and 2nd are devoid of a marginal spine. Wolfenden (1911, p. 199) states that "am Innenaste fehlen auch die ausseren Randborsten des 1. und 2. Gliedes," but this is clearly an error and it is the outer branch that he is referring to.

In the 2nd–4th pairs of legs (Text-fig. 4, B) both rami are composed of three segments, and the 3rd segment of the exopod bears 3 marginal spines. The distal segment of the endopod is thickly clad with hairs.

In the 5th leg (Text-fig. 4, C) the rami are also composed of 3 segments, but in this case there are only two marginal spines on the 3rd segment of the exopod.

Remarks.—Sars (1925, p. 16) claims that this form is identical with that described by him under the name *Bathycalanus richardi*. I (1929, p. 31, 1932, pls. i and ii) have recorded the occurrence of Sars' species from the Bay of Bengal, these individuals clearly showing the characteristic fusion of the 2nd and 3rd segments in the exopod of the 1st leg in the female. Since this difference appears to be constant, it seems best, as Farran (1939, p. 359) has done, to regard the two forms as separate, though very closely related, species.

Distribution.—An extensive area throughout the deep water of the Atlantic, north and south of the equator, from 1500 to 3000 metres' depth (Wolfenden); it would thus seem to be an inhabitant of the North Atlantic Intermediate water, and in all probability, like the preceding species, has been carried round the Cape of Good Hope into the Indian Ocean and then in the Antarctic Bottom Drift up into the Gulf of Oman.

Bathycalanus sp., juv. (Text-fig. 5, A–H.)

Occurrence.—Sta. 131 D, Central area of Arabian Sea, 1500–0 m., 1 juv., copepodid stage V.

Descriptive Notes.—Total length, 7·9 mm.

The proportional lengths of the cephalothorax and abdomen are as 75 to 25. The proportional lengths of the various segments of the body are as follows :

Cephalothorax.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.	
346	104	95	78	53	74	42	70	49	49	40	= 1000

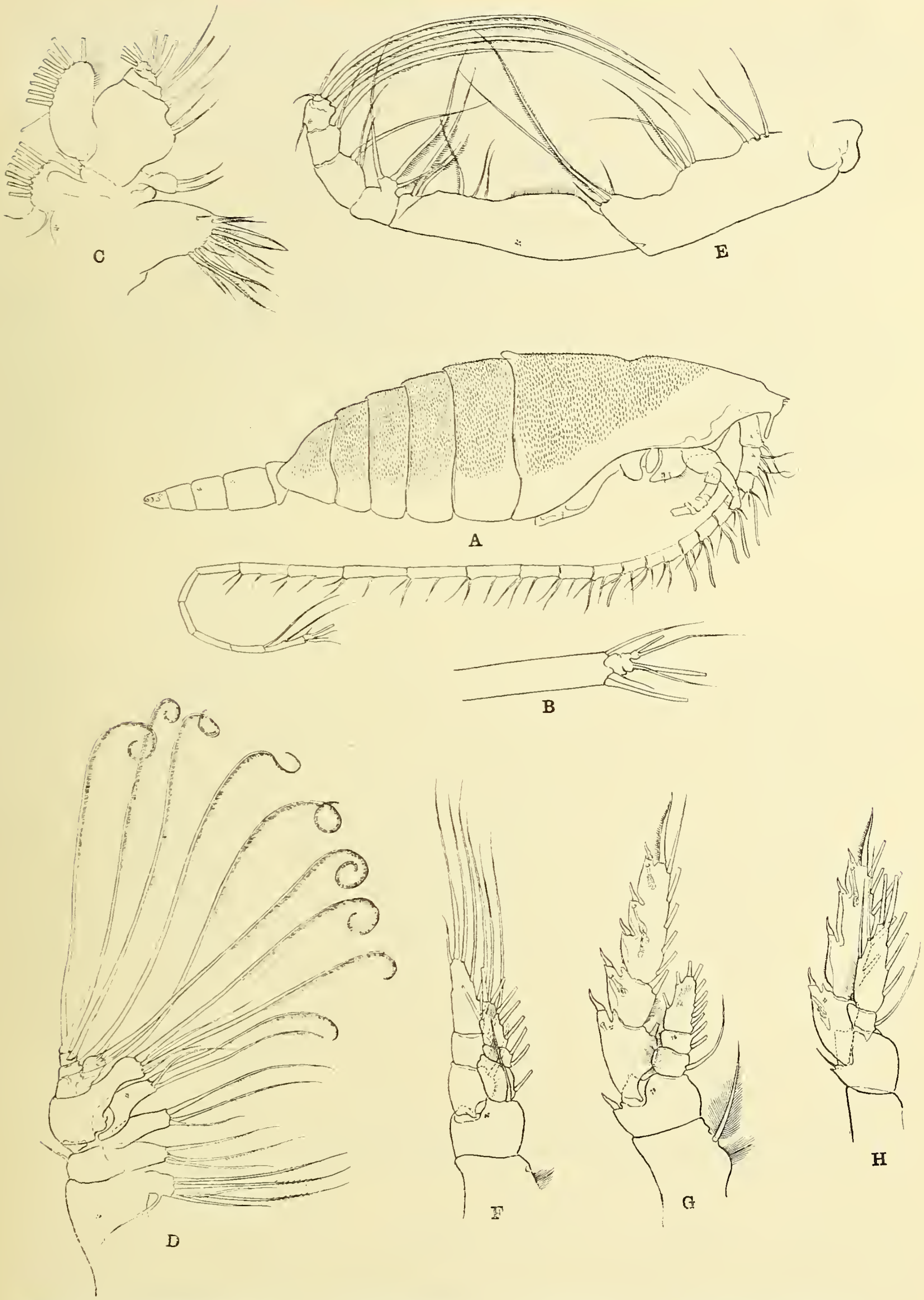
In the proportions and general shape of the body this young form (Text-fig. 5, A) closely resembles the adult *B. bradyi* (Wolfenden). The head rapidly tapers in front of the origin of the 1st antenna. The posterior margin of the cephalon is produced in the mid-dorsal line in a rounded protuberance. The 4th and 5th thoracic segments are separate, and the posterior thoracic margin is rounded. The dorso-lateral region of the cephalon in the posterior three-fourths of its length and of all the thoracic segments is ornamented with numerous short, raised ridges, that in the main run transversely. The rostrum resembles that of the adult, and consists of a pair of stout sausage-like organs without any terminal seta-like projections.

In the abdomen the 1st and 2nd segments are separate, but the 4th and 5th are still fused. I have been able to detect a single " macula " in the dorso-lateral region of the 2nd and 3rd abdominal segments, and another near the base of the outer furcal seta.

The 1st antenna over-reaches the tip of the furcal ramus by the last 5 or 6 segments. The proportional lengths of the segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
	42	27	16	18	24	23	21	17	21	29	29	37	47	54	57	60	62

18.	19.	20.	21.	22.	23.	24.	25.	
67	69	47	50	54	52	27	50	= 1000.



TEXT-FIG. 5.—*Bathycalanus* sp., Copepodid State V. A, Lateral view. B, Terminal portion of 1st antenna. C, 1st maxilla. D, 2nd maxilla. E, Maxilliped. F, 1st leg. G, 2nd leg. H, 5th leg.

The 8th and 9th segments are partially fused. The terminal portion of the end segment (Text-fig. 5, B) strongly supports the view that this segment is composed of several, probably three, segments fused together.

The mouth-parts resemble those of the adult (Text-fig. 5, C, D and E).

The 1st leg (Text-fig. 5, F) resembles that of *B. bradyi*, and differs from *B. richardi* in that the exopod is clearly composed of three separate segments.

The 2nd–4th legs (Text-fig. 5, G) possess the usual structure.

In the 5th leg (Text-fig. 5, H) both exopod and endopod are composed of only two segments, segments 2 and 3 not yet having separated.

Remarks.—In spite of its relatively small size, as compared with the adult, it seems probable that this example is a young stage of *Bathycalanus bradyi* (Wolfenden). The presence of all three segments in the exopod of the 1st leg is a character that not only shows its affinity with *B. bradyi*, but also indicates that Rose (1929, p. 13) is wrong when he remarks, " Or Wolfenden observe 3 articles à l'exopodite de la 1re patte de *B. maximus* ♀, et c'est le charactère essentiel qui permettrait de séparer les 2 formes. En fait, il parait plus vraisemblable d'admettre que Sars n'a vu que des individus non complètement adultes, où la 1re patte présente encore des charactères larvaires."

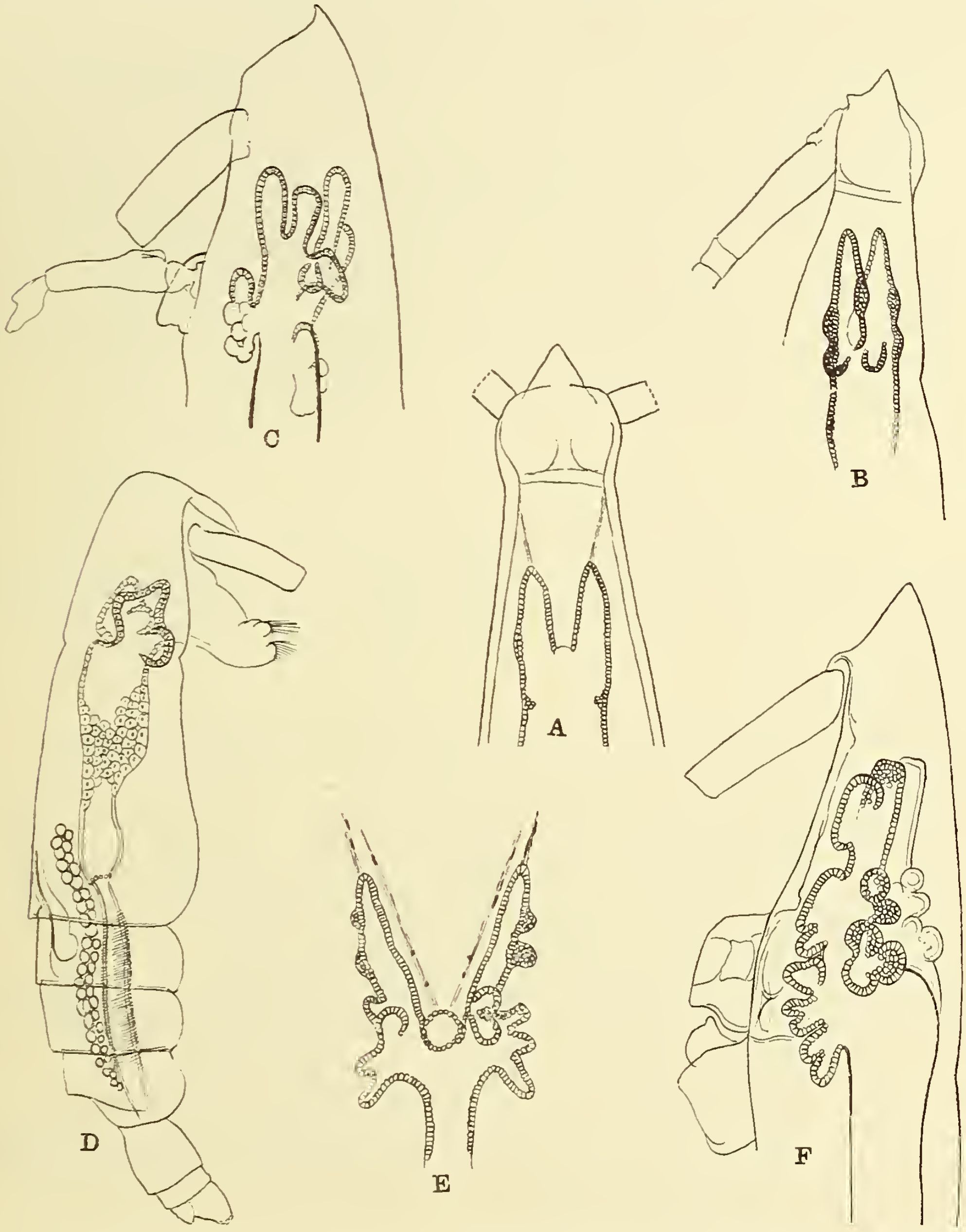
Family Eucalanidæ.

Genus *Eucalanus* Dana. (Text-fig. 6, A–F.)

Throughout this genus there is a steadily progressive development of the gastric cavity. Calman (1909, p. 92) states that " in many Gymnoplea there is a short median diverticulum anteriorly and, in some cases, immediately behind this a pair of small lateral (hepatic) cæca, which may be bifid (*Eucalanus*)." The simplest form of stomach that I have examined in this genus is to be found in the species *Eucalanus pseudattenuatus* sp. nov. (Text-fig. 6, A, B), in which there is a small, median, rounded diverticulum dorsally, and extending forward on either side of this is a simple digitiform diverticulum, the wall of which is composed of a single layer of cubical cells except at two points, one on the dorsal and the other on the ventro-lateral aspect, where the endothelium is thickened.

The next stage of development and the one which corresponds to the description given by Calman is reached in *Eucalanus crassus* and *E. subcrassus* (Text-fig. 6, D). With (1915, p. 53, pl. i, fig. 7) has described the cæcal diverticula arising from the anterior region of the gastric cavity in *Eucalanus crassus* as being " divided into smaller parts " ; in his figure he shows a short and broadly rounded, median diverticulum and, arising from the gastric cavity near the base of this, on either side, a larger diverticulum with a smaller one arising more posteriorly and projecting in the ventro-lateral direction. It thus would perhaps be more correct to say that in these species there is a median diverticulum and a pair of diverticula on either side, an antero-lateral pair and a ventro-lateral pair. In *Eucalanus subcrassus* the condition appears to be very similar, but the anterior paired diverticula are more pyriform than rounded, the narrow anterior end projecting forwards and downwards. In *Eucalanus mucronatus* (Text-fig. 6, C) the condition has become still more complicated. The median dorsal diverticulum is now bifid, and below and in front of this pair there is, on either side, an unequal pair of diverticula that project forwards ; these appear to correspond to the antero-lateral and ventro-lateral pairs of diverticula in

E. subcrassus. Still further back in the ventro-lateral region there is now a new development, having the appearance of a glandular mass, that is indistinctly tri-lobed, and of which the anterior part is produced in a small anteriorly-directed diverticulum.



TEXT-FIG. 6.—The gastric cavity in A, *Eucalanus pseudattenuatus* sp. nov., dorsal view. B, *Eucalanus pseudattenuatus* sp. nov., oblique side view. C, *Eucalanus mucronatus*, side view. D, *Eucalanus subcrassus*, side view. E, *Eucalanus attenuatus*, Stage V, dorsal view. F, *Eucalanus attenuatus* adult, side view.

Finally, the greatest degree of complexity that, up to the present, I have been able to examine, is to be found in *Eucalanus attenuatus*. Claus (1863, p. 59) pointed out that the shape and evolution of the alimentary canal might change very considerably in a single species, and in this instance there is a marked increase in the complexity of the

organ as we pass from Stage V in the female to the Adult Stage VI. In Stage V (Text-fig. 6, E) the condition present resembles somewhat the stage reached in *E. mucronatus*; there is a short, median diverticulum, and on either side of this a long, digitiform diverticulum runs forwards and outwards; the wall of this latter is thickened in two areas on the outer aspect. At the base of this antero-lateral diverticulum there is on each side a smaller diverticulum, single on the left side in the specimen examined but bifurcate on the right; this diverticulum appears to correspond to the ventro-lateral diverticulum of *E. crassus* and *subcrassus*. More posteriorly in the ventro-lateral region there is a more complicated diverticulum that appears to be subdivided into three smaller cæca. In Stage VI (Text-fig. 6, F) the thickened endothelial areas of the antero-lateral diverticula have now developed into secondary pouches, and at the proximal end of this diverticulum on the dorsal aspect a group of sudsidiary pouches has made its appearance and the posterior diverticulum in the ventro-lateral region has become still more complicated, for the posterior two cæca have themselves become bifid. We thus have a complicated structure that very markedly resembles the hepato-pancreas of the Malacostraca.

Eucalanus attenuatus (Dana). (Text-fig. 7, B.)

Eucalanus attenuatus, Giesbrecht, 1892, p. 131, pl. iii, fig. 1, pl. xi, figs. 1, 11, 13, 16, 18, 24, 40, pl. xxxv, figs. 3, 6, 17, 25, 34 and 37; van Breemen, 1908, p. 16, fig. 12 *a–d*; Sewell, 1925, p. 48; Vervoort, 1946, p. 95.

Occurrence:

Sta. 61 C, Northern area of Arabian Sea, surface; 19 females, 7 males.
Sta. 76, Gulf of Oman, 600 m., 50 specimens.
Sta. 96, Central part of Arabian Sea, 645–400 m., 182 females, 119 males.
Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 6 females.
Sta. 172, Central part of Arabian Sea, 200–0 m., 2 females; 400–0 m., 217 females, 33 males; 850–0 m., 329 females, 144 males.
Sta. 186, Gulf of Aden, 500–700 m., 65 females, 74 males.

Descriptive Notes.—The present examples agree closely with the description given by Giesbrecht and others. In a few examples of mature females the genital segment is furnished in the postero-lateral regions with a group of small spinules.

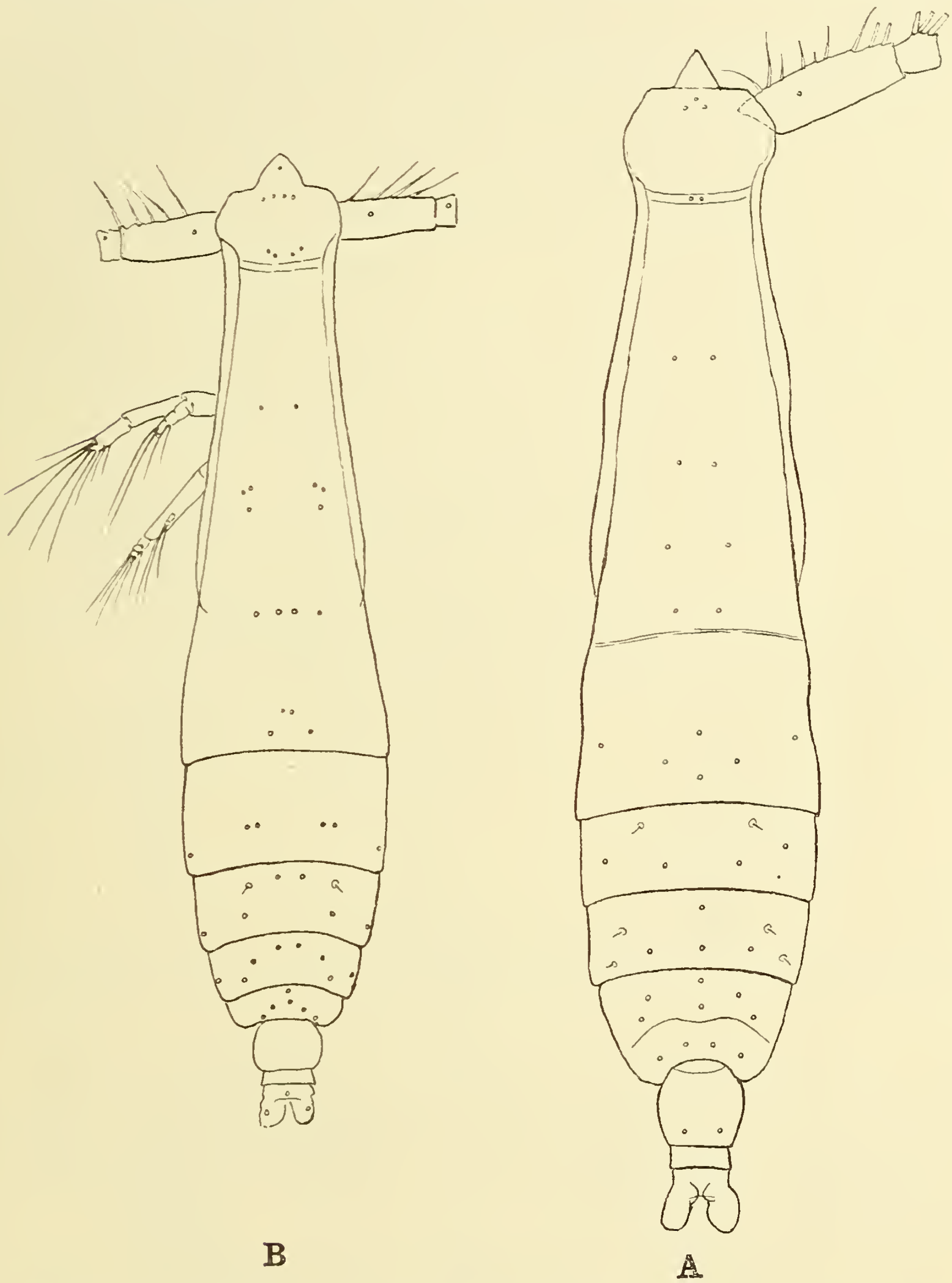
The presence of glands, opening through small pores in the cuticle of the cephalothorax and abdomen, has been recorded in a number of species belonging to several genera and families from both fresh-water and marine habitats, and I have (1932) described the distribution of such pores in the following:

Family Temoridæ, Genus *Temora*.
,, Metridiidæ, Genera *Metridia*, *Gaussia* and *Pleuromamma*.
,, Heterorhabdidæ, Genera *Heterorhabdus*, *Hemirhabdus* and *Disseta*.
,, Lucicutiidæ, Genus *Lucicutia*.

A number of such pores are present in the above species, scattered over the head, thorax and abdomen, as shown in Text-fig. 7, B.

Distribution.—This species possesses an extremely wide range occurring in all the

great oceans. In the Pacific it has been recorded from the San Diego region (Esterly), the Pacific Ocean and China Sea (Dana), off New Zealand in lat., 34°–35° S. (Farran) and in the Malay Archipelago (Cleve, Vervoort); it is extraordinary that neither this species nor the



TEXT-FIG. 7.—The cutaneous pores in A, *Eucalanus pseudattenuatus* sp. nov. B, *Eucalanus attenuatus*.

closely related *Eucalanus elongatus* were recorded among the " Siboga " collections from the Malay Archipelago by A. Scott (1909). In the Indian Ocean it has been taken in the Moscos Archipelago off the coast of S. Burma, in the Bay of Bengal (Sewell, Menon), the Laccadive Sea (Sewell), from Ceylon to the Red Sea (Thompson and A. Scott), the Arabian

Sea and the Gulf of Aden (present records), and off the African coast between Port Natal and Simonstown (Wolfenden), the Arabian Sea and Gulf of Aden (Cleve) and the Agulhas Current off South Africa (Cleve). In the Atlantic Ocean it occurs between 35° S. and 40° N. (Wolfenden), in the Gulf of Guinea (T. Scott), off S. America in lat. 30°–40° S. (Farran), at several stations in the North Atlantic (Sars, Rose), in the Mediterranean Sea (Claus, Rose), and off the Irish Atlantic slopes in lat. 55° N. (Farran). Thompson (1898) recorded it from the Faroe Channel, and Wolfenden (1902) also included it in the list of Copepoda taken in that locality; Fowler (1898 and 1903), relying on Thompson's identification, indicated that this species is an ingredient of both the Epi-plankton and the Meso-plankton. Wolfenden (1904) later came to the conclusion that the sample from the Faroe Channel in which this species had been found "had become contaminated with some material from the Indian Ocean" and that the only species from the Faroe Channel is the closely related *Eucalanus elongatus*.

The vertical distribution of this species appears to extend from 0 to 3000 fathoms (5486 m.). In the Indian Ocean its depth range appears to be considerably less, extending from the surface down to about 1250 metres, with a maximum intensity at about 400–800 metres. It has been recorded in water of salinity ranging from 36.27 °/₀₀ to 10·86 °/₀₀ in the Gulf of Oman and the Gulf of Guinea respectively.

The statement made by Wolfenden (1906, p. 996) that in the Maldive Archipelago this species "entirely replaces *E. elongatus* characteristic of the North Atlantic" is without foundation.

There appears to be a very considerable difference in the number of examples of this species that are present in different regions. In the following table I have given the total numbers captured in the eastern and western areas of the Arabian Sea:

Depth. (m.)	Affected area. Stas. 61 A and C, 76.	Unaffected area. Stas. 96, 172 and 186.
0–200	26	2
200–600	50	551
600–1000	0	612
1000–1500	0	0

It thus seems clear that in the southern and central areas conditions are much more favourable than in the Gulf of Oman region, especially between 600–1000 metres depth.

Eucalanus pseudattenuatus sp. nov. (Text-fig. 7, A, and Text-fig. 8, A–F.)

Associated with the last species in the collections were numerous specimens that exhibit an extremely close resemblance, differing, in the main, in size but also showing certain slight anatomical differences.

OCCURRENCE:

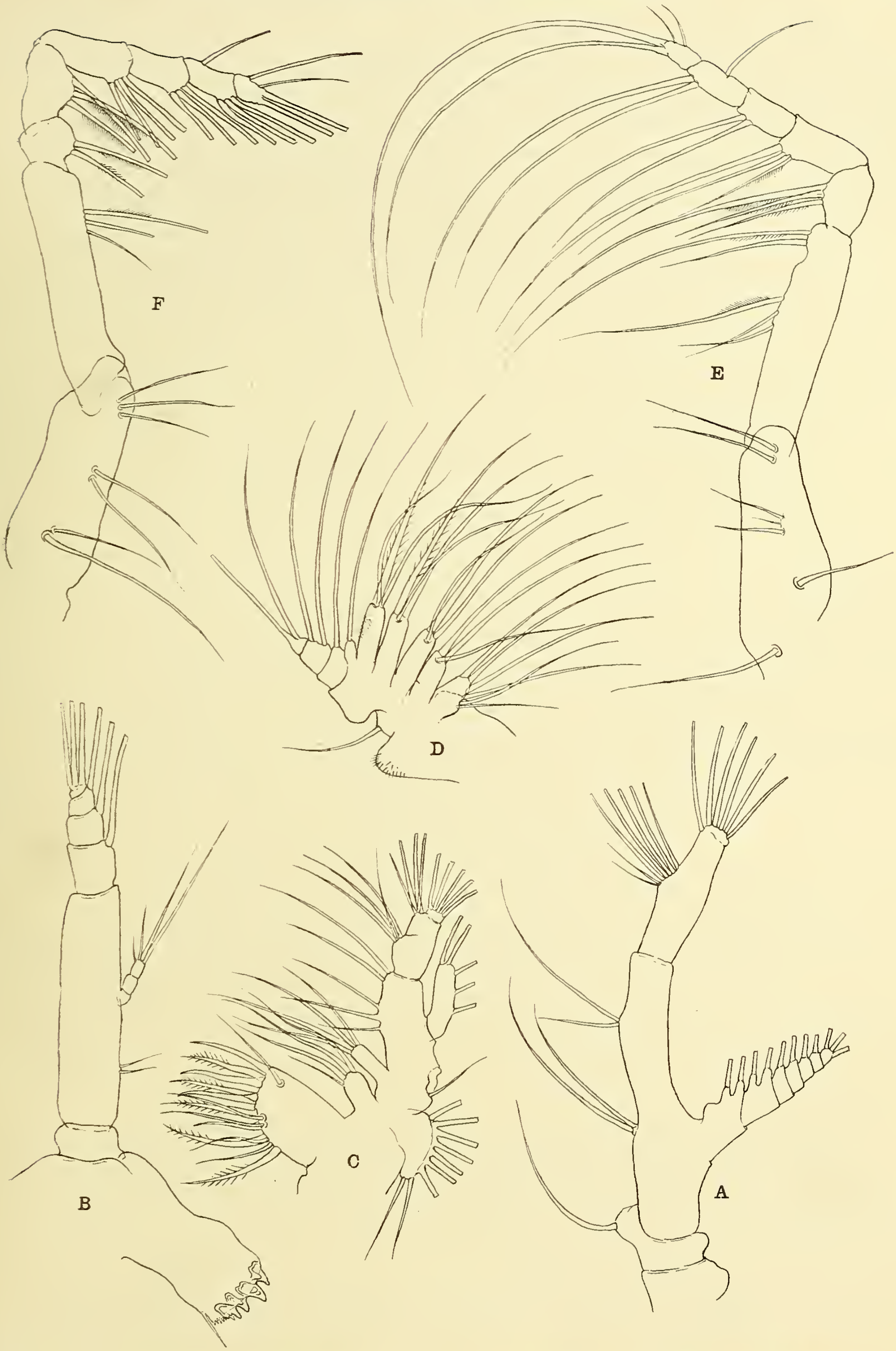
Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 7 examples.

Sta. 61 C, Northern area of Arabian Sea, surface, 112 females, 3 males (adult), 9 males (Stage V); 1500–0 m., 15 specimens.

Sta. 96, Central area of Arabian Sea, 645–400 m., 4 specimens.

Sta. 145, Maldive area, 500–0 m., 1 specimen.

Sta. 172, Central part of Arabian Sea, 400–0 m., 5 specimens; 850–0 m., 7 specimens.



TEXT-FIG. 8.—*Eucalanus pseudattenuatus* sp. nov., ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, 2nd maxilla. E, Maxilliped, Stage V. F, Maxilliped, adult.

Descriptive Notes.—The total length of the females ranges from 3·00 to 3·383 mm. in Stage V, and from 3·318 to 4·250 mm. in the adult; in the males the length is 2·463 mm. at Stage V and 3·067 mm. at Stage VI.

♀. In its general form the body very closely resembles that of *Eucalanus attenuatus* (Dana), but the anterior region of the head is more markedly constricted in front of the attachment of the 1st antennæ, and the extreme anterior end is sharply pointed and is usually bent somewhat downwards. The cephalon and 1st thoracic segments are fused, but in stained specimens the line of junction is indicated by a narrow unstained line. Thoracic segments 4 and 5 are not completely separate, being fused together in the ventro-lateral region. The genital segment of the abdomen consists of the fused three anterior segments, and when viewed from the dorsal aspect is about as long as wide; ventrally it projects in a rounded swelling, bearing the genital aperture. Between the genital and anal segments is one free segment. The anal segment and furcal rami are fused. The 2nd seta on the left furcal ramus is markedly stouter and much longer than the others.

As in *E. attenuatus*, the external cuticle is pierced by a number of small pores, that open on the dorso-lateral region of the cephalon and thoracic segments, and on the dorsal region of the genital segment of the abdomen; the arrangement of these pores is shown in Text-fig. 7, a.

The 1st antenna consists of 23 separate segments, segments 1 and 2 and 8 and 9 respectively being fused. As in *Eucalanus attenuatus*, the terminal segment, 25th, is extremely long.

The proportional lengths of the individual segments are as follows, and for the purpose of reference I have also given those of the appendage in *E. attenuatus*:

Segment	1–2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.
pseudattenuatus .	120	25	25	26	26	28	52	35	42	47	50	51	51	51	50
attenuatus . .	120	28	26	27	27	28	55	36	40	50	52	53	53	52	51

Segment	18.	19.	20.	21.	22.	23.	24.	25.	
pseudattenuatus	48	47	42	38	29	37	27	53	= 1000.
attenuatus	49	46	41	38	28	32	23	55	= 1000.

The 2nd antenna (Text-fig. 8, a) is similar to that of *E. attenuatus*.

The mandible (Text-fig. 8, b) closely resembles that of *E. attenuatus*; the exopod arises from near the middle of the 2nd basal segment and bears 4 setæ, of which the inner is long and the outer very short and delicate. Two small setæ spring from the inner margin of the 2nd basal segment about half way between the proximal end and the origin of the exopod.

The 1st and 2nd maxillæ (Text-figs. 8, c and d) appear to be identical with those of *E. attenuatus*.

The maxilliped (Text-fig. 8, e and f) exhibits differences in the Vth and VIth stages. As Lebour (1916) has shown in *Calanus finmarchicus*, the number of setæ arising from the 2nd, 3rd and 4th segments of the endopod is increased at this moult; the same is true of the present species:

Segments of endopod		1.	2.	3.	4.	5.
Stage V:	Number of setæ	3	3	2	2(1)	2(2).
Stage VI:	,, ,,	3	4	3	3(1)	2(2).

The setæ shown in brackets arise from the outer margin.

The swimming legs are similar to those of *E. attenuatus.*

♂. Only four adult examples were obtained. In their general appearance these agree extremely closely, except as regards size, with the male of *E. attenuatus.* As in that species, the anterior region, instead of being acutely pointed, is rounded. The abdomen consists of four free segments and the combined anal segment and furcal rami.

There are a pair of legs present on the 5th thoracic segment, the right being comparatively short and being composed of only three segments, whereas the left is long and is composed of four segments. The terminal segment of each leg bears a single seta.

I have been in some doubt as to whether these smaller examples should be regarded as a distinct species, or merely as a depauperized form of *E. attenuatus.*

In previous papers I have shown that there is a gradual change in the proportions of the various parts of the body at each successive moult; in typical examples of *E. attenuatus* we get the following changes in the proportional lengths of each segment of the body as we pass from stage V to the adult Stage VI :

♀.	Cephalon and Th. segment I.	Thoracic segments. II.	III.	IV.	V.	Abdominal segments. I–III.	IV.	V + furca.
Stage V :	643	76	67	46	43	61	17	47
Stage VI :	612	85	73	53	49	62	19	47

In *E. pseudattenuatus,* however, the proportional lengths of the various segments of the body in the last two stages of development are as follows :

♀.	Cephalon and Th. segment I.	Thoracic segments. II.	III.	IV.	V.	Abdominal segments. I–III.	IV.	V + furca.
Stage V :	645	79	68	50	39	65	14	40
Stage VI :	645	72	66	50	38	63	19	47

Thus the relative length of the cephalon in this form approaches more nearly to that found in Stage V in the true *attenuatus,* but there is little or no difference in the proportional lengths of the abdominal segments.

In the two forms the average length measurements of the two last stages in the female and the corresponding growth-factors are as follows :

	Stage V.	Stage VI.	Growth-factor.
E. attenuatus	4·407 mm.	5·275 mm.	1·196
E. pseudattenuatus	3·298 ,,	3·838 ,,	1·164

In addition to these differences there are certain small differences in structure :

(i) The arrangement of the pores, opening on the cuticle, is different.

(ii) The head is more acutely pointed in *E. pseudattenuatus.*

(iii) The gastric cavity is of a simpler type in *E. pseudattenuatus* than in *E. attenuatus.*

In these circumstances it seems best to regard the two forms as representing different species.

Eucalanus elongatus (Dana).

Eucalanus elongatus, Giesbrecht, 1892, pp. 131, 148, pl. xi, figs. 2, 7, 12, 20, 25, 32, 36, pl. xxxv, figs. 1, 2, 13, 23, 24 ; van Breemen, 1908, p. 14, fig. 10 ; With, 1915, p. 48, pl. i, figs. 5 *a–d*, text-fig. 9 *a–f* ; Sewell, 1929, p. 48, fig. 13; Vervoort, 1946, p. 84.
Eucalanus atlanticus, Wolfenden, 1904, p. 113, pl. ix, figs. 3, 4.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 4 specimens ; 1500–0 m., 100 specimens.

Sta. 61 C, Northern area of Arabian Sea, 1000–0 m., 33 specimens ; 1500–0 m., 43 specimens ; 2000–0 m., 1 specimen.

Sta. 71, Gulf of Oman, 106 m. ; 3 females.

Sta. 76, Gulf of Oman, 200–0 m., 41 females, 10 males ; 600–0 m., 2061 females, 29 males ; 1500–0 m., 351 specimens.

Sta. 96, Central area of Arabian Sea, 645–400 m., 254 females, 4 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 3 females.

Sta. 145 C, Maldive area, 300–0 m., 8 females, 1 male ; 500–0 m., 2 males.

Sta. 145 D, Maldive area, 300–0 m., 1 female ; 500–0 m., 2 females.

Sta. 172, Central area of Arabian Sea, 200–0 m., 260 females, 3 males ; 400–0 m., 302 females ; 850–0 m., 556 females, 11 males.

Sta. 186, Gulf of Aden, 250–0 m., 191 specimens ; 575–0 m., 830 specimens ; 600–0 m., 2741 females, 8 males.

Descriptive Notes.—All the females examined belonged to the variety first described by Giesbrecht (1895, p. 246) and later noted by Esterly (1905, p. 132, fig. 6 b), in which the posterior lateral margin of the 5th thoracic segment is rounded and does not exhibit the small spine of the typical form. Both of these records come from the Pacific Ocean, and it would appear possible that this variety is in reality an Indo-Pacific form.

The outstanding feature of the collection is the great paucity of males as compared with the females, as is clearly shown in the table below :

	Females.	Males.
Sta. 76, depth 200 metres	41	10
Sta. 172, ,, 200 ,,	260	3
Sta. 172, ,, 400 ,,	302	0
Sta. 96, ,, 645–400 metres	254	4
Sta. 76, ,, 600 metres	2061	29
Sta. 186, ,, 600 ,,	2741	8
Sta. 172, ,, 850 ,,	556	11
Totals	6215	65

In every case that I have examined the male is in the last Copepodid stage—Stage V—and agrees exactly with the male described by Wolfenden (1904, p. 113, figs. 3 and 4) from the Atlantic Ocean under the name *Eucalanus atlanticus*; no mature males were found.

Distribution.—The species has a wide range. It has been recorded in the Pacific

Ocean at several stations off the west coast of South America from Valparaiso northwards (Giesbrecht), and from the San Diego region (Esterly); on the west side of this ocean it has been taken in Long, 132° W. between lats. 14° N. and 3° S. (Giesbrecht); it is common off New Zealand as far south as 62° 41′ S. (Farran), and also occurs off the Australian Barrier Reef (Farran), and in the Malay Archipelago (Vervoort).

In the Indian Ocean it occurs round the Nicobar Islands (Sewell), in the Bay of Bengal (Sewell), off the Madras coast (Menon), in the Laccadive Sea (Sewell), in the Arabian Sea (present records). and to the north of Prince Edward Island, in lat. 47° S. In the Atlantic Ocean it has been taken in long. 2° E., in the latitude of Tristan da Cunha, and in lat. 19° S. and long. 20° W. to the east of Trinidad, and at numerous stations in the North Atlantic (Wolfenden, Sars), while further north it occurs off the Azores and in the Bay of Biscay (Farran), to the east of the Shetland Islands and in the North Seas (Farran), as far east as the Skagerrak (van Breemen), to the south-west of Iceland and in East and West Greenland waters (Jespersen). It also occurs in the Mediterranean Sea (Sars, Rose). Its occurrence in the North Sea and the Shetland region is due, according to Farran (1911), to "its being carried out of the area in which it normally lives and breeds into regions where it must ultimately perish."

Its depth distribution ranges from the surface down to about 4000 metres; but it is interesting to note that it appears to occur at considerably greater depths on the western sides of the oceans than on the eastern sides; in the Pacific Ocean Esterly found that the plurimum was at about 366 metres (200 fathoms), whereas Giesbrecht, in long. 132° W., took it in 4000 metres. In Indian waters, it was plentiful at 732 metres (400 fathoms) in the Bay of Bengal and at 366 to 1280 metres (200–700 fathoms) in the Laccadive Sea, whereas in the Arabian Sea the plurimum seems to lie at about 600 metres and it occurs well below 500 metres; off Prince Edward Island it occurred at 250 metres' depth. In the Atlantic Ocean it occurred at 3000 metres' depth in the southern area, while in the northern region its depth range is from 0–5000 metres; it was taken between 150–1000 metres' depth off Iceland, but as deep as 1000–3000 metres to the west of Greenland (Jespersen). It thus appears probable that in the North and South Atlantic Ocean it is an inhabitant in the main of the North Atlantic Intermediate Current, whereas off Prince Edward Island and in the Arabian Sea it occurs mainly in the Sub-Polar Intermediate Current.

In the present collection there is a very marked difference in the number of examples that have been taken in different regions. This is well shown in the following table:

Depth. m.	Affected area. Stas. 61 A and C, 96.	Unaffected area. Stas. 76, 172 and 186.
0–200	0	304
200–600	258	6162
600–1000	37	567
1000–1500	144	351
1500–2000	1	0

It thus seems clear that conditions in the north-west part of the Arabian Sea are much more favourable to this species than in the eastern region.

Eucalanus crassus Giesbrecht.

Eucalanus crassus, Giesbrecht, 1892, p. 132, pl. iv, fig. 9, pl. xi, figs. 8, 10, 17, 21, 22, 38, pl. xxv, figs. 4, 20, 26–28; van Breemen, 1908, p. 16, fig. 13 *a–d*; Vervoort, 1946, p. 112.

Occurrence :

Sta. 76, Gulf of Oman, 200 m., 16 specimens; 600 m., 9 females; 1500 m., 7 females, 1 male.

Sta. 96, Central part of Arabian Sea, 10 m., 2 females.

Sta. 172, Central part of Arabian Sea, 850 m., 1 female.

Distribution.—This species has an extremely wide distribution; it has been recorded from all the great oceans. In the Pacific it has been taken on the east side off San Diego (Esterly), off the coast of South America between 14° and 26° S., and on the west side of the ocean from 175° W. to 138° E. between 19° and 20° N. (Giesbrecht), and on the Great Barrier Reef of Australia (Farran). It has been taken in the Malay Archipelago (Cleve, A, Scott, Sewell). In the Indian Ocean it has been recorded from the coast of Southern Burma (Sewell), the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the central area of the Arabian Sea and the Gulf of Oman (present records), the Gulf of Aden and the Red Sea (Thompson and A. Scott, Cleve), and off the east coast of Cape Colony (Cleve). In the Atlantic it has been taken between 30° and 40° S. (Farran), off Rio de Janeiro (Giesbrecht) and Pernambuco (T. Scott), in the Mediterranean Sea (Giesbrecht), the Bay of Biscay and the Irish coast (Farran), in the North Atlantic as far north as 57° 46′ N. (With) and off the Faroe Islands (Wolfenden).

Its vertical distribution appears to range from the surface down to 1500 metres. Farran records it from the surface to below 914 metres (500 fathoms) in the Bay of Biscay.

Eucalanus monachus Giesbrecht.

Eucalanus monachus, Giesbrecht, 1892, p. 132, pl. xi, fig. 37, pl. xxxv, figs. 5, 14, 33, 36; Sars, 1925, 22; Sewell, 1929, p. 51.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 5 females, 13 males (all immature).

Distribution.—This species has been recorded from the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean it has been taken off the coast of south Burma (Sewell), at several stations in the Bay of Bengal (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), in the Maldive Archipelago (Wolfenden), in the Arabian Sea (Cleve, present record), the Gulf of Aden and Red Sea (Cleve), east of Cape Colony (Cleve). In the Atlantic it occurs in the tropical region (Wolfenden), in the North Temperate region (Rose), off Woods Hole (Wilson), off Gibraltar (Giesbrecht), in the western Mediterranean (Giesbrecht and Schmeil, Rose), and in the Adriatic Sea (Pesta).

Eucalanus mucronatus Giesbrecht.

Eucalanus mucronatus, Giesbrecht, 1892, p. 132, pl. xi, figs. 9, 26, 34, pl. xxv, figs. 15, 35, and 38; Vervoort, 1946, p. 104.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m. depth.

Sta. 76, Gulf of Oman, 1500–0 m.

Sta. 96. Central part of Arabian Sea, 10 m. depth, 645–400 m. depth.

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., vertical haul.

Sta. 145 C, Maldive area, 500–0 m., vertical.

Sta. 172, Central part of Arabian Sea, 400–0 m. and 850–0 m. depth.

Distribution.—In the Pacific Ocean between 16° and 19° N. (Giesbrecht), off New Zealand 30°–40° S. (Farran), Great Barrier Reefs of Australia (Farran), Malay Archipelago (A. Scott). In the Indian Ocean it is widely distributed, having been reported from the Nicobar and Andaman Islands (Sewell), the Ceylon Pearl Banks (Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (present records), the Gulf of Aden and Red Sea (Cleve), and east of Cape Colony (Cleve). It has also been taken in the Atlantic Ocean near the Azores (Sars).

Eucalanus pileatus Giesbrecht.

Eucalanus pileatus, Giesbrecht, 1892, p. 132, pl. xi, figs. 3, 28, 41, pl. xxxv, figs. 7, 8, 19, 39–41.

Occurrence.—Sta. 61, Northern area of Arabian Sea, surface.

Remarks.—A few examples of both this species and *E. subtenuis* Giesbr. are infected with a parasite that appears to be *Balantidium contortum* Chatton (*vide* Chatton, 1920, p. 175).

Distribution.—In the Atlantic and Pacific Oceans between 10° N. and 20° S. (Giesbrecht and Schmeil); Malay Archipelago (A. Scott). In the Indian Ocean, coast of Southern Burma (Sewell), the Nicobar Islands (Sewell), the Ceylon Pearl Banks (Sewell), the Laccadive Sea (Thompson and A. Scott), the Maldive Archipelago (Wolfenden), the coast of Southern Arabia (present record), the Red Sea (Thompson and A. Scott), the east coast of Cape Colony (Cleve). In the South Atlantic to the south of St. Helena and between St. Helena and Ascension Island (Wolfenden).

Eucalanus subcrassus Giesbrecht.

Eucalanus subcrassus, Giesbrecht, 1892, p. 132, pl. xi, figs. 6, 14, 18, 30, 39, pl. xxxv, figs. 12, 16, 31, 32; Sewell, 1929, p. 51, figs. 14–17; Vervoort, 1946, p. 108.

Occurrence :

Sta. 61 C, Northern part of Arabian Sea, surface, several females.

Sta. 96, Central part of Arabian Sea, 10 m. depth, 2 females.

Distribution.—This species has a wide distribution, occurring in all three great oceans. In the Pacific it has been recorded from the west of South America between lats. 3° S. and 10° N., and from Hongkong and Amoy (Giesbrecht), the Australian Barrier Reef, where it is plentiful (Farran), and from the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean it has been recorded from off Penang, the coast of Southern Burma, several stations in the Bay of Bengal (Sewell), the Madras coast of India (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea and Gulf of Aden (Cleve), the Persian Gulf (Pesta), the Red Sea (Giesbrecht, Cleve), and from the east of the Cape of Good Hope (Cleve). In the Atlantic Ocean it has been taken in the Tropical Atlantic off Rio de Janeiro (Farran) and in the North Atlantic (Wolfenden): it does not extend as far north as *E. crassus*, for it has not been recorded off Norway by Sars, nor from the Irish coast by either Farran or Pearson.

Eucalanus subtenuis Giesbrecht.

Eucalanus subtenuis, Giesbrecht, 1892, p. 132, pl. xi, figs. 4, 23, 42, pl. xxxv, figs. 9–11, 18, 29 and 30; Vervoort, 1946, p. 106.

Occurrence.—Sta. 61, Northern part of Arabian Sea, surface.

Distribution.—In the Pacific Ocean from the San Diego Region (Esterly), the eastern area between 15° N. and 26° S. down to 4000 metres (Giesbrecht), and the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean from the Burma coast (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott), the Maldive Archipelago (Wolfenden) and the Arabian Coast (present record). In the Atlantic Ocean between 30° N. and 26° S. (Giesbrecht and Schmeil), 14° N. to 2° S. (T. Scott, Farran), 10° S. (Wolfenden), near the Azores (Sars) and near Cape Verde Islands (Giesbrecht).

Genus *Rhincalanus* Dana.

Rhincalanus cornutus Dana, forma *typica* Schmaus.

Rhincalanus cornutus, Giesbrecht, 1892, p. 153, pl. xii, figs. 13, 15, pl. xxxv, figs. 45, 48; Sewell, 1929, p. 58.
Rhincalanus cornutus, f. *typica*, Schmaus, 1917, p. 312, figs. 5–11; Schmaus and Lehnhofer, 1927, pp. 259, 265; Vervoort, 1946, p. 116.

Occurrence:

- Sta. 96, Central area of Arabian Sea, 10–0 m., 867 examples; 645–400 m., 71 examples.
- Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 26 specimens; 1500–0 m., 25 examples.
- Sta. 145 C, Maldive area, 100–0 m., 3 examples; 300–0 m., 8 examples; 500–0 m., 2 examples.
- Sta. 145 D, Maldive area, 50–0 m., 1 example; 100–0 m., 12 examples; 300–0 m., 4 examples; 500–0 m., 10 examples.
- Sta. 172, Central area of Arabian Sea, 200–0 m., 57 examples; 400–0 m., 55 examples; 850–0 m., 129 examples; 2040 m., 1 example.
- Sta. 186, Gulf of Aden, 250–0 m., 1 example; 570–0 m., 12 examples; 600–0 m., 10 examples.

Descriptive Notes.—All the present examples agree with the description given by Schmaus (1917) of the form that he has termed f. *typica*. A single female, adult, was obtained at Sta. 96, 10 metres depth, in which the lateral spine on each side of the 4th thoracic segment was double.

Distribution.—As Schmaus and Lehnhofer (1927, p. 382 *et seq.*) have pointed out, this form of *Rhincalanus cornutus* is in the main confined to the Pacific and Indian Oceans, and is for the most part an inhabitant of the warm equatorial region, though it has been taken in the Pacific as far north as the coast of Japan, and in the Indian Ocean as far south as lats. 64° 37′ S., long. 108° 50′ E., and lat. 63° 28½′ S., long. 90° 22′ E. (Brady).

The vertical range of this species extends from the surface down to 1000 metres depth, but it is the young stages that are taken in the upper levels, while the adults are for the most part to be found at depths below 200 metres (*vide* Schmaus and Lehnhofer, 1927, p. 392, fig. 29). The present results agree with this, and it seems probable that reproduction was in full swing near the surface at Sta. 96, in the month of December, for most of the examples taken near the surface were immature, and some were in the late nauplius stages;

it is probable that there is a second breeding period in April, for it was in these two months only that adult males were obtained, and even then they were extremely rare, two examples being taken in December and one in April.

The prevalence of the species appears to vary very considerably in different parts of the area investigated, as is indicated in the following table :

Depth. m.	Number of examples taken. Stas. 96, 172.	Stas. 131 D, 186.
0–200	867	0
200–400	57	27
400–600	126	22
600–800	129	25
800–1200	1	0

The large numbers of examples occurring at or near the surface in December at Sta. 96 will be swept in a westwardly or south-westwardly direction by the north-east monsoon currents, and as these individuals sink downwards with increasing age they will enter the Sub-Polar Intermediate Current and again be carried northwards and eastwards.

Rhincalanus nasutus Giesbrecht.

Rhincalanus nasutus, Giesbrecht, 1892, p. 152, pl. iii, fig. 6, pl. ix, figs. 6, 14, pl. xii, figs. 9–12, 14, 16, 17, pl. xxxv, figs. 46, 47, 49 ; Sars, 1901, p. 15, pls. vi, vii ; Wilson, 1932, p. 34, fig. 18 ; Vervoort, 1936, p. 122.

Occurrence :

Sta. 61 A, Northern are of Arabian Sea, 1000–0 m., 7 specimens ; 1500–0 m., 6 specimens.

Sta. 61 C, Northern area of Arabian Sea, 1000–0 m., 2 specimens ; 1500–0 m., 2 specimens.

Sta. 76, Gulf of Oman, 200–0 m., 44 specimens ; 600–0 m., 803 specimens ; 1500–0 m., 278 specimens.

Sta. 96, Central area of Arabian Sea, 10 m., 13 specimens ; 645–400 m., 942 specimens.

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 specimen.

Sta. 145 D, Maldive region, 500–0 m., 1 specimen.

Sta. 172, Central area of Arabian Sea, 200–0 m., 667 specimens ; 400–0 m., 744 specimens ; 850–0 m., 1249 specimens ; 2090–0 m., 11 specimens.

Sta. 186, Gulf of Aden, 250–0 m., 167 specimens ; 575–0 m., 361 specimens ; 600–0 m., 1137 specimens.

Remarks.—Schmaus and Lehnhofer (1927) have called attention to the vertical distribution of this species in the Indian Ocean, and have pointed out that the temperature range extends from 3° C. to 20° C., the maximum density of distribution occurring at a depth of about 1000 metres ; this agrees very well with the present observations. In the following table I have given the numbers taken at different depths in two regions of the Arabian Sea, namely, the Gulf of Oman Region (Stas. 61 and 76) and in the central and southern area (Stas. 96, 172 and 186) ; in the former there is marked reduction in the numbers obtained.

Depth. m.	Affected area. Stas. 61 A and C, and 76.	Unaffected area. Stas. 96, 172 and 186.
0–250	44	858
250–600	803	2884
600–1000	9	1249
1000–1500	8	..
1500–2000	0	11

It is thus clear that the maximum concentration is found at about 600–1000 metres depth, and that the range extends from close to the surface down to 1500 metres. This appears to be considerably deeper than the distribution in both the Atlantic and eastern Pacific regions; in the former area Farran (1926, p. 232) and Lysholm and Nordgaard (1921, p. 9) give the depth distribution as from the surface to 400 fathoms (0–732 metres) with a plurimum at 200–300 fathoms (366–549 metres), and from 400–1000 metres respectively, whereas in the eastern Pacific Esterly (1912, p. 317) states that "the plurimum during the day is between 100 and 200 fathoms (183 to 366 metres), though the abundance at 200–250 (366–457 metres) is a little greater." Our results clearly show that conditions at Sta. 61 in the North-Eastern Region are very different from those at the other stations, for here only 17 examples in all were taken at depths of between 500–2000 metres, whereas at the other stations we obtained at these depths no less than 4947 specimens (*vide* appendix).

Distribution.—In the Pacific Ocean between the Straits of Magellan and the Gulf of California (Farran), the San Diego region (Esterly), Southern Pacific Ocean (Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott). In the Indian Ocean, the Bay of Bengal (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Laccadive Sea (Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (Thompson and A. Scott, Cleve, present records), Gulf of Aden and Red Sea (Cleve), and the east coast of S. Africa (Cleve). In the Atlantic Ocean between Cape Colony and 65° N. (Farran), in the South Atlantic, 30°–40° S. (Farran), the North Atlantic (Farran, Sars, Cleve), the western Mediterranean (Giesbrecht), the Bay of Biscay (Farran), the North Sea (Sars), west coast of Ireland (Farran), Iceland (Sars), the east coast of America, the Gulf of Maine (Bigelow), Woods Hole region and Chesapeake Bay (Wilson), and East Greenland (Jespersen).

Farran (1911) remarks: "As far as concerns its distribution in the N.E. Atlantic it may be regarded as an inhabitant of the Atlantic Current, its distribution to the north and east depending on the varying strength of that stream."

Schmaus and Lehnhofer (1927) have clearly shown that it is largely an inhabitant of the N. Atlantic Intermediate Current in the Atlantic Ocean and of the Indian Tropical Intermediate Current in the Indian Ocean. In their charts of the vertical distribution of the species of this genus (Schmaus and Lehnhofer, 1927, p. 392, figs. 28 and 29) they have shown a break in the occurrence of this species between lats. 9° N. and S. in the Atlantic Ocean, and lats. 5° N. and S. in the Indian Ocean; but the correctness of this view is extremely doubtful; they have themselves shown that 21 examples of *R. nasutus* (♀♀) were taken in the Altantic in lat. 1° 51′ N. and 54 (♀♀) and 11 (juv.) were captured in the Indian Ocean in lat. 0° 16′ N.

Family Paracalanidæ.

Genus *Paracalanus* Boeck.

Paracalanus aculeatus Giesbrecht.

Paracalanus aculeatus, Giesbrecht, 1892, p. 164, pl. ix, figs. 20, 26, 30; Sewell, 1929, p. 62, figs. 20, 21; Vervoort, 1946, p. 127.

Occurrence:

Sta. 61 C, Northern area of the Arabian Sea, surface, 10,680 examples.

Sta. 96, Central area of Arabian Sea, 14–0 m., 2 females, 1 male, 1 juv.

Remarks.—A number of specimens are infected with a parasite that appears to be *Blastodinium contortum* Chatton (*vide* Chatton, 1920, p. 175).

Distribution.—Widely distributed throughout the tropical and temperate regions of all three oceans. In the Pacific it has been recorded from several stations in the eastern area and from the western side between 10° N. and 10° S., from Hongkong (Giesbrecht), the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl) and the Malay Archipelago (A. Scott). In the Indian Ocean it has been taken off the coast of S. Burma, the Andaman and Nicobar Islands and the Ceylon Pearl Banks (Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (A. Scott, present record), the Gulf of Aden and Red Sea (Giesbrecht, A. Scott), and the east coast of Africa (Cleve). It has also been taken in the Atlantic Ocean in the Gulf of Guinea (T. Scott as *P. parvus*), the South Atlantic between 30° and 40° S. (Farran), in the tropical part of the Atlantic Ocean (Giesbrecht, Farran) and off Cape Verde Islands (Sars).

Paracalanus denudatus Sewell.

Paracalanus denudatus, Sewell, 1929, p. 66, fig. 23; Farran, 1936, p. 80, fig. 1, *b*.

Occurrence:

Sta. 61, North part of Arabian Sea, surface; A (day), 240 specimens, C (night), 8280 specimens.

Sta. 96, Central area of Arabian Sea, 14–0 m., 3 females.

Remarks.—This species was described by me from specimens taken in the Andaman and Nicobar Islands. It has since been recorded by Farran from the Barrier Reefs of Australia, where it was "probably the most abundant species in the collections made at 3 miles E. (of Low Isles), occurring in large numbers in all the fine-meshed nets from which samples of the smaller species were available." The present record extends its range westward to the northern area of the Arabian Sea, and it is probably widely distributed throughout the western Pacific and Indian Oceans.

Paracalanus parvus Giesbrecht.

Paracalanus parvus, Giesbrecht, 1892, p. 164, pl. i, fig. 5, pl. vi, figs. 28–30, pl. ix, figs. 5, 11, 25, 27, 31 and 32; Sewell, 1929, p. 68, figs. 24 and 25; Vervoort, 1946, p. 130.

Occurrence: Sta. 61, North part of Arabian Sea, surface, C (night), 2760 specimens.

Remarks.—Wolfenden (1906*b*, p. 997) has called attention to the fact that in this species slight differences can be detected in specimens from the Indian and Mediterranean regions on the one hand and the North Atlantic on the other; he has termed these two

forms var. *borealis* and var. *indicus* respectively. As one would expect, the northern boreal form is larger than the tropical or sub-tropical form, the respective sizes being 1·0–1·1 mm. in *borealis* and 0·8–1·0 mm. in *indicus*. In a species with such a wide distribution some variation in structure is only to be expected, and it is possible that there are two geographical races, similar to the races that are known to have evolved in the species *Rhincalanus cornutus*, namely, an Indo-Pacific form that has spread into the Mediterranean through the Suez Canal, and an Atlantic form.

A number of examples are infected with a parasite that appears, usually, to be identical with *Blastodinium contortum* Chatton (*vide* Chatton, 1920, p. 175), but in a few instances the parasite resembled *Blastodinium contortum hyalinum* Chatton (*loc. cit.*, p. 193, fig. 200).

Distribution.—In the Pacific Ocean from the tropical region of the eastern area (Giesbrecht) and from 61° N. to 52° S. (Sars), the San Diego Region and San Francisco Bay (Esterly), Hong-Kong (Giesbrecht), off New Zealand (Brady, Farran), the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl) and the Malay Archipelago (A. Scott). In the Indian Ocean from the coast of S. Burma (Sewell), the Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Red Sea (Thompson and A. Scott), the Suez Canal (Gurney), Durban Bay, E. Africa (Brady). In the Antarctic Ocean from the Auckland Islands and as far South as 64° 30′ S. (Brady). In the Atlantic Ocean from the tropics and north and south temperate regions as far as 30°–40° S. (Farran), the North Temperate region (Rose), the Mediterranean Sea (Giesbrecht, Thompson and A. Scott, Rose), the Adriatic (Steuer, Früchtl) and the Black Sea (Farran), the Bay of Biscay (Farran), the coast of Devon and Cornwall (Norman and T. Scott), the Irish coast (Farran), the North Sea (Claus, Bourne, Pesta), the west part of the Baltic, Christiania Fjord and the south coast of Norway (Sars), the east coast of North America, Chesapeake Bay (Wilson), Woods Hole (Wilson), and Gulf of Maine (Bigelow), the Faroe Channel, Iceland and E. Greenland (With).

It is able to survive in a comparatively wide range of salinity, having been taken in waters of a salinity of 19·33 °/₀₀ and 35·26 °/₀₀ (Farran).

Genus *Acrocalanus* Giesbrecht.

This genus is represented by five species, namely:

Acrocalanus gracilis Giesbrecht.
A. *gibber* Giesbrecht (= *A. pediger* Cleve ♀).
A. *longicornis* Giesbrecht (? = *A. gardineri* Wolfenden ♂).
A. *monachus* Giesbrecht.
A. *inermis* Sewell.

All of these have now been taken in the region of the Malay Archipelago and the Indian Ocean. *Acrocalanus inermis* appears to be in the main an inhabitant of brackish water, but the rest are pelagic. As one traces the distribution of the genus westwards the number of species that have been recorded gradually falls off; Gurney (1927*a*, p. 147) states that five species have been recorded from the Red Sea, but I have been able to trace references to only three, namely, *Acrocalanus gibber*, *gracilis* and *longicornis*; and of these only *A. gibber* appears to have reached the Gulf of Suez and has entered the Suez Canal,

where it has spread as far as Ras-el-Ech. Only one species has so far been recorded from the Atlantic Ocean, namely, *A. longicornis*, which is reported by Farran in the collections of the " Terra Nova " from the tropical region, but was absent off Rio de Janeiro, and by T. Scott in those of the " Scotia " between 20° N. and 32° S.

Acrocalanus gracilis Giesbrecht.

Acrocalanus gracilis, Giesbrecht, 1892, p. 171, pl. vi, fig. 27, pl. x, fig. 35 ; Sewell, 1929, p. 79, fig. 31; Vervoort, 1946, p. 134.

Occurrence :

Sta. 61, North part of Arabian Sea, surface.

Sta. 136, Maldive area, surface, 23 females (adult), 6 female juv. and 1 male juv.

Remarks.—A few specimens from Sta. 61 were infected with a parasite that appears to be *Balantidium contortum* Chatton (*vide* Chatton, 1920, p. 175).

Distribution.—The Pacific Ocean between 20° N. and 20° S. (Giesbrecht), the Great Barrier Reefs of Australia (Farran), the Aru Archipelago (Früchtl), and the Malay Archipelago (A. Scott). In the Indian Ocean the coast of S. Burma and the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden, present record), the Arabian Sea (Thompson and A. Scott, present record), the Red Sea and Gulf of Suez (Thompson and A. Scott), and the east coast of S. Africa (Cleve, Wolfenden).

Acrocalanus longicornis Giesbrecht.

Acrocalanus longicornis, Giesbrecht, 1892, p. 171, pl. vi, figs. 25, 33, pl. x, figs. 34, 36 and 39 ; Sewell, 1929, p. 82, fig. 33 ; Wolfenden, 1906, p. 1000, pl. xcvii, figs. 1, 6, 11–13, 22–24 ; Vervoort, 1946, p. 133.

Occurrence :

Sta. 61, North part of Arabian Sea, surface ; A (day), 360 specimens ; C (night), 360 specimens.

Sta. 96, Central part of Arabian Sea, 10 m. depth, 2 females.

Distribution.—The east and west Pacific Ocean between lats. 15° N. and 10° S. (Giebrecht), the Great Barrier Reefs of Australia (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean, the coast of S. Burma and the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (Giesbrecht, present records), the Persian Gulf (Pesta), the Red Sea (Thompson and A. Scott), and the east coast of Africa (Brady). In the Atlantic Ocean in both tropical and temperate regions (Farran), and between 20° N. and 32° S. (T. Scott).

Acrocalanus monachus Giesbrecht.

Acrocalanus monachus, Giesbrecht, 1892, p. 171, pl. vi, fig. 26, pl. x, fig. 38 ; Wolfenden, 1906, p. 1002, pl. xcvii, figs. 4, 9, 27 and 28.

Occurrence.—Sta. 61, North part of Arabian Sea, surface.

Distribution.—In the Pacific Ocean between 5° and 9° N. (Giesbrecht), the Great Barrier Reefs of Australia (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean on the coast of S. Burma (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (present record), and the east coast of S. Africa (Cleve).

Family Pseudocalanidæ.

Genus *Calocalanus* Giesbrecht.

Calocalanus pavo (Dana).

Calocalanus pavo, Giesbrecht, 1892, p. 175, pl. i, fig. 13, pl. iv, fig. 15, pl. ix, figs. 3, 4, 13, 19, pl. xxxv, figs. 43–45 ; Vervoort, 1946, p. 138.

Occurrence :

Sta. 61, North area of Arabian Sea, surface, many examples.

Sta. 96, Central part of Arabian Sea, 10 m., 2 females.

Distribution.—Throughout all three great oceans. In the Pacific Ocean at several Stations in the eastern region and on the west side between 3° S. and 19° N. (Giesbrecht), off New Zealand and the Great Barrier Reefs of Australia (Farran), in the Aru Archipelago (Früchtl) and in the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean on the coast of S. Burma and the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (A. Scott, present records), the Red Sea (Giesbrecht, A. Scott). In the Atlantic Ocean in the southern area (Wolfenden), between 30° S. and 26° N. (T. Scott), the tropical and temperate regions to 40° S. (Farran), the Gulf of Guinea (T. Scott), Cape Verde Islands (Dana), Canary Islands (Thompson), the North Atlantic (Thompson and A. Scott), in the Mediterranean Sea (Giesbrecht, Thompson and A. Scott), the Adriatic (Steuer, Pesta, Früchtl), Malta (Thompson) and the Woods Hole region of N. America (Wheeler, Sharpe, Wilson).

Calocalanus plumulosus (Claus).

Calocalanus plumulosus, Giesbrecht, 1892, p. 176, pl. iii, fig. 5, pl. ix, figs. 2, 22, pl. xxxvi, figs. 39–42 ; Wilson, 1932, p. 41, fig. 23.

Occurrence.—Sta. 61, North part of Arabian Sea, surface, several examples.

Remarks.—♀. Total length ranges from 1·039 mm. to 1·083 mm., with an average length of 1·058.

Distribution.—In the Pacific Ocean between lats. 0° and 11° N. (Giesbrecht), off New Zealand and the Great Barrier Reefs of Australia (Farran), in the Aru Archipelago (Früchtl) and the Malay Archipelago (A. Scott). In the Indian Ocean from the coast of S. Burma and the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive Archipelago (Wolfenden), the Arabian Sea (A. Scott, Thompson and A. Scott, present record), the Red Sea (A. Scott). In the Atlantic Ocean (Wolfenden), the Gulf of Guinea (T. Scott), the Mediterranean Sea (Giesbrecht, Thompson and A. Scott), the Adriatic (Pesta), the eastern Mediterranean (Pesta), the Gulf Stream (Wheeler), and the Woods Hole region of the North American coast (Wilson).

Genus *Clausocalanus* Giesbrecht.

Clausocalanus arcuicornis (Dana).

Clausocalanus arcuicornis, Giesbrecht, 1892, p. 186, pl. i, fig. 14, pl. ii, fig. 7, pl. x, figs. 3–8, 14, 16, 17, 19, pl. xxxvi, figs. 29–31, 34 ; van Breemen, 1908, p. 23, fig. 20 ; Farran, 1926, p. 237, pl. vi, figs. 1–3 ; Vorvoort, 1946, p. 140.

Occurrence.—Sta. 61 C, Northern region of Arabian Sea, surface, numerous examples.

Remarks.—A few examples were infected with a parasite that appears to be *Blastodinium contortum hyalinum* Chatton (*vide* Chatton, 1912, p. 193).

Distribution.—In the Pacific Ocean from the west coast of S. America (Giesbrecht), the San Diego Region and San Francisco Bay (Esterly), in the open ocean between 20° N. and 26° S. and off Hong-Kong (Giesbrecht), the Antarctic region and New Zealand (Farran), the Great Barrier Reefs of Australia (Farran), the Aru Archipelago (Früchtl), the Malay Archipelago (A. Scott). In the Indian Ocean on the coast of S. Burma (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Cleve, Thompson and A. Scott, present record), the Red Sea (Thompson and A. Scott), Suez Bay and the south end of the Suez Canal (Gurney), the east coast of S. Africa (Cleve). In the Atlantic Ocean as far south as 46° S. (T. Scott), throughout the temperate and tropical regions (Farran), in the North Atlantic (Thompson and A. Scott, Sars, van Breemen, Rose), Gulf of Guinea (T. Scott), the Mediterranean Sea (Claus, Giesbrecht, Thompson and A. Scott, Rose), the Adriatic (Steuer, Früchtl), the eastern Mediterranean (Pesta), the Bay of Biscay (Farran), the west coast of Ireland (Farran), the Gulf Stream (Wheeler), and South of Iceland in lat. 59° N., long 17° W. (With).

Clausocalanus farrani Sewell.

Clausocalanus farrani, Sewell, 1929, p. 94, fig. 38 ; Farran, 1936, p. 81.

Occurrence.—Sta. 61, North area of Arabian Sea, surface, many examples

Distribution.—This species has now been taken off the Great Barrier Reefs of Australia (Farran), the coast of S. Burma (Sewell) and the Arabian Sea (present record). It is in all probability widely distributed throughout the western Pacific and Indian Oceans, and Farran suggests that it is sub-oceanic in habitat.

Clausocalanus furcatus (Brady).

Clausocalanus furcatus, Giesbrecht, 1892, p. 186, pl. xxxvi, figs. 32, 33 and 35 ; Esterly, 1911*a*, p. 223, pl. i, figs. 2, 7, 9, pl. ii, fig. 3, pl. iii, fig. 33, and pl. iv, figs. 36, 40 and 44 ; Vervoort, 1946, p. 144.

Occurrence.—Sta. 61 C, North region of Arabian Sea, surface, 11,280 examples.

Remarks.—A number of specimens from Sta. 61 are infected with a parasite that appears to be *Balantidium contortum* Chatton (*vide* Chatton, 1920, p. 175). In several examples the number of parasites was multiple :

2 specimens	contained	2	parasites.
1 specimen	,,	4	,,
2 specimens	,,	8	,,
3 ,,	,,	10	,,
1 specimen	,,	11	,,
1 ,,	,,	12	,,

It seems probable that these latter forms were examples of either *B. spinulosum* Chatton or *B. pruroti* Chatton.

Distribution.—In the Pacific Ocean west of S. America (Brady), the east and west regions between 20° N. and 26° S. (Giesbrecht), off New Zealand (Brady), the Australian

Barrier Reefs (Farran), off Cape Howe (Brady), the Aru Archipelago (Früchtl) and the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean off the coast of S. Burma (Sewell), the Andaman and Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, A. Scott, present record), the Red Sea (Thompson and A. Scott, A. Scott, Giesbrecht), Durban Bay (Brady), the east coast of S. Africa (Cleve). In the Antarctic from south of Tasmania, off Macquarie Island, and as far south as 64° 30′ S. (Brady). In the Atlantic Ocean between 22° N. and 26° S. (T. Scott), the temperate and tropical regions (Farran, Rose), the Gulf of Guinea (T. Scott), south-west of Sierra Leone (Brady), the Canary Islands (Thompson), Bermuda (Esterly), the North Atlantic (Thompson and A. Scott, Rose), the western Mediterranean (Giesbrecht, Rose), the eastern Mediterranean (Pesta).

Family ÆTIDEIDÆ.

Genus *Gætanus* Giesbrecht.

Gætanus, Giesbrecht, 1892, p. 219.

At the present time this genus includes the following species :

Gætanus antarcticus Wolfenden.
G. armiger Giesbrecht (= *atlanticus* Wolfenden).
G. brachyurus Sars.
G. brevicaudatus Wolfenden.
G. brevicornis Esterly (= *rectus* Wolfenden, *ascendens* Esterly).
G. caudani Canu.
G. curvicornis Sars.
G. divergens Wolfenden.
G. ferox With, ♂ only.
G. hamatus A. Scott.
G. inermis Sars.
G. kruppi Giesbrecht (= *clarus* Esterly).
G. latifrons Sars (= *holti* Farran, *longispinus* Wolfenden).
G. major Wolfenden.
G. miles Giesbrecht.
G. minor Farran (= *minimus* Wolfenden).
G. pileatus Farran (= *caudani* Auct., ? *unicornis* Esterly).
G. recticornis Wolfenden.
G. robustus Sars.
G. secundus. Esterly.

In addition to the above, Brady (1918) has recorded what he considered to be a new species from the Antarctic under the name *Gætanus antarcticus*, ignoring the fact that this name was already preoccupied by Wolfenden's species from the same region, described in 1905. Brady's description is totally inadequate, but the very short abdomen of his species presents a resemblance to *G. brachyurus* Sars.

A number of species are shown in the above list as synonyms. The form originally described by Canu under the name *caudani* is immature, and according to Sars (1925, p.

56) and With (1915, p. 104) the form recorded by subsequent authors under this name is identical with *G. pileatus* Farran. A. Scott (1909, p. 46) believes that *G. unicornis* Esterly is also a synonym of this species, but With (1915, p. 107) does not agree with this. *Gætanus clarus* Esterly is, accordingly to A. Scott and With, the male of *G. kruppi* Giesbrecht. According to Sars (1925, p. 61) and A. Scott (1909, p. 48) *G. major* Wolfenden is a synonym of *G. kruppi* Giesbrecht, but according to Wolfenden there is in his form no lamella on the 1st basal segment of the maxilliped, so that this is doubtful. *Gætanus atlanticus* Wolfenden is a synonym of *G. armiger* Giesbrecht ; and *G. minimus* Wolfenden is probably a synonym of *G. minor* Farran.

It also seems probable that *Gætanus divergens* Wolfenden and *G. hamatus* A. Scott may be synonyms ; according to Wolfenden (1911, p. 226) in *divergens* the lamella on the 1st basal segment of the maxilliped is without the usual process, and A. Scott (1909, p. 50) in his account of *hamatus* states that the lamella was like that of *latifrons* (in which species the lamella is also without a process), but that "the preparation was slightly damaged during dissection, and the apex of the lamella was destroyed."

As regards the remaining species, *Gætanus ferox* With, known only from the male, is doubtfully referred to this genus, the 5th pair of legs more nearly resembling those of a *Gaidius*. *Gætanus robustus* Sars differs from other members of the genus in the absence of a spine on the forehead, and appears to be closely related to, if not identical with, the form described by Wolfenden under the name *Mesogaidius maximus*. *Gætanus inermis* Sars, as Wolfenden (1908, p. 32) has pointed out, is in all probability not a *Gætanus* at all ; Giesbrecht's definition of the genus gives as one of the characters the presence of spines on the head and on the sides of the 5th thoracic segment, and the complete absence of these in *G. inermis* Sars thus necessitates either a modification of the definition of the genus or the removal of this species to another genus, and possibly the creation of a new one, to accommodate it.

These various species can be grouped according to the character of the exopod of the 1st leg, and the shape and size of the lamella on the 1st segment of the maxilliped :

Group I. The exopod of the 1st leg is composed of two segments only.

A. The 1st antenna is very long, twice the length of the body or more.

Gætanus miles Giesbrecht.
G. recticornis Wolfenden.
? *G. secundus* Esterly.

B. The 1st antenna is longer than the body by $1\frac{1}{2}$ times or by the last 7 segments.

Gætanus pileatus Farran.

C. The 1st antenna is shorter than the body and reaches only to the 2nd abdominal segment.

Gætanus minor Farran.

Group II. The exopod of the 1st leg is incompletely divided into three segments, the division between segments 1 and 2 not being complete ; segment 1 is without a marginal spine.

A. The 1st basal segment of the maxilliped is without a lamella.

Gœtanus armiger Giesbrecht.
G. major Wolfenden.

B. The lamella on segment 1 of the maxilliped is crest-like and is not produced distally in a lobe.

Gœtanus divergens Wolfenden.

C. The lamella on basal 1 of the maxilliped is produced in a rounded or pointed lobe, which does not reach as far as the distal end of the segment.

Gœtanus kruppi Giesbrecht.
G. hamatus A. Scott.
? *G. secundus* Esterly.

D. The lamella on the 1st basal segment of the maxilliped is produced in a narrow ribbon-like process that reaches as far as or even beyond the distal end of the segment.

Gœtanus brevicornis Esterly.

Group III. The exopod of the 1st leg is composed of three segments, all of which bear marginal spines.

A. The lamella on the 1st basal segment of the maxilliped is crest-like and is not produced in a lobe.

Gœtanus antarcticus Wolfenden.
G. latifrons Sars.
G. curvicornis Sars.

B. The lamella on the 1st basal segment of the maxilliped is produced in a rounded lobe.

Gœtanus brevicaudatus Wolfenden.
? *G. secundus* Esterly.

It will be noticed that *Gaetanus secundus* Esterly appears in all three groups; the reason for this is that Esterly in his account of this species gives no description of the 1st leg, and merely states that "the swimming feet do not show any marked peculiarities." *Gœtanus brachyurus* and *G. robustus* both fall in Group III, for Sars states that in both these species the 1st leg is perfectly formed; he, however, makes no mention of the character of the lamella on the maxilliped.

Group I.

Gœtanus miles Giesbrecht.

Gœtanus miles, Giesbrecht, 1892, p. 219, pl. xiv, figs. 21, 24, 25, 27, 30, pl. xxxvi, fig. 3; Thompson, 1903, p. 17, pl. i, figs. 3–5; van Breemen, 1908, p. 39, fig. 42.

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 6 females, adult ; 1 male, juv.

Sta. 145 C, Maldive area, 300–0 m. vertical, 2 females.

Sta. 172, Central part of Arabian Sea, 850–0 m., 2 females.

Distribution.—In the Pacific Ocean between 3° S. and 16° N., and 99°–115° W. (Giesbrecht), off the Great Barrier Reefs of Australia (Farran) and in the Malay Archipelago (A. Scott). In the Indian Ocean in the Bay of Bengal and Laccadive Sea (Sewell) and in the central region of the Arabian Sea (present records). In the Atlantic Ocean in 36° S. (Wolfenden), in the North Atlantic (Thompson, Farran, Sars, Rose), in the Gulf of Maine (Bigelow), off Georges Bank on the American Coast (Wilson), to the south of Iceland (With) and in Baffin Bay (Jespersen).

The vertical range appears to extend between the surface and some 4000 metres depth. Farran gives its range in the Bay of Biscay as 274–366 metres, but Thompson in the " Oceana " Collection to the west of the British Isles records it from depths as great as 3054 metres, and Sars has recorded it from the surface.

Gætanus minor Farran.

Gætanus minor, Farran, 1905, p. 34, pl. v, figs. 1–11 ; A. Scott, 1909, p. 47, pl. ix, figs. 1–8 ; Sars, 1925, p. 60, pl. xviii, figs. 3, 4.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female, adult.

Distribution.—In the Pacific Ocean in Suruga Bay, Japan (Tanaka), off New Zealand and the Great Barrier Reefs of Australia (Farran) and in the Malay Archipelago (A. Scott). In the Indian Ocean in the Laccadive Sea (Sewell) and in the Arabian Sea (present record). In the South Atlantic Ocean (Wolfenden), off the Azores (Sars) and off the Irish coast (Farran).

The vertical range appears to extend from the surface down to 2745 metres depth ; Farran states that in the Bay of Biscay its normal range is from 275 to 450 metres, but at night it may ascend to within 90 metres of the surface, and he captured it on the surface in two hauls off New Zealand.

Gætanus pileatus Farran.

Gætanus pileatus, Farran, 1903, p. 120 (16), pl. xvii, figs. 1–11 ; Wolfenden, 1911, p. 229, pl. xxvii, figs. 1, 2, text-fig. 17 ; With, 1915, p. 104, fig. 26 ; Sars, 1925, p. 56, pl. xvii, figs. 3–6 ; Sewell, 1929, p. 103, fig. 40.

Gætanus caudani, Wolfenden, 1904, p. 114, pl. ix, figs. 20–22 ; A. Scott, 1909, p. 46, pl. viii, figs. 9–15, pl. ix, fig. 3.

? *Gætanus unicornis*, Esterly, 1906, p. 57, pl. xii, fig. 54, pl. xiii, fig. 76.

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 3 females, adult, 1 juv.

Sta. 131 D, Southern part of Arabian Sea, 500–0 m. vertical haul, 1 female, juv. ; 1500–0 m. vertical haul, 1 female, juv.

Sta. 172, Central part of Arabian Sea, 400–0 m., 2 females, adult, 1 juv. ; 850–0 m., 1 female, juv.

Distribution.—In the Pacific this species has been taken off the Great Barrier Reef of Australia (Farran), in the Malay Archipelago (A. Scott) and, if Esterly's *G. unicornis*

is a synonym, as A. Scott believes, it occurs also in the San Diego region. In the Indian Ocean it has been taken in the Laccadive Sea (Sewell) and in the Arabian Sea (present records). In the Atlantic Ocean it occurs in the South Atlantic (Wolfenden), the North Atlantic (Sars), the Bay of Biscay (Farran), the west coast of Ireland (Farran), in the warm area of the Atlantic between 51° and 60° N. (Wolfenden), in the Faroe-Iceland Channel, to the south of Iceland and in Denmark Strait as far as 65° N. (With).

The vertical range appears to extend from about 183 metres down to some 2000 metres. In the Bay of Biscay it occurred between 183 and 1372 metres, with an optimum at 274–549 metres (Farran), and to the south-west of the Faeroes it is abundant at 600 metres depth (With).

Group II.

Gœtanus brevicornis Esterly. (Text-fig. 9, a, b.)

Gœtanus brevicornis, Esterly, 1906, p. 56, pl. ix, fig. 4, pl. xii, fig. 55.
Gœtanus rectus, Wolfenden, 1911, p. 232, pl. xxvi, figs. 14–16, text-fig. 18 ; Sewell, 1929, p. 105.
Gœtanus ascendens, Esterly, 1913, p. 182, pl. x, figs. 1, 3, 6, pl. xi, fig. 39, pl. xii, fig. 56.

Occurrence :

Sta. 131 D, Southern area of the Arabian Sea, 1500–0 m., 1 female, adult.

Sta. 172, Central part of the Arabian Sea, 850–0 m., 1 female, adult.

Descriptive Notes.—♀. Total length, 4·26 and 4·98 mm. Esterly gives the length of the single female that he obtained as 4·3 mm. ; Wolfenden's two specimens, taken in the tropical area of the Atlantic Ocean, were somewhat smaller, measuring only 3·5 mm.

The proportional lengths of the cephalothorax and abdomen are as 77 to 23. The proportional lengths of the various segments of the body are as follows :

Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
518	74	74	94	90	47	33	33	37 = 1000

The anterior horn is directed downwards and forwards, as in *G. armiger* Giesbrecht, and in the present specimens is somewhat stouter than in that species ; Wolfenden states that in his examples of *G. rectus* it is less stout. The lateral horns on the 5th thoracic segment are rather short and stout, and are directed somewhat outwards and upwards. The genital segment is swollen ventrally, and this and the two following segments are fringed along their posterior margins with closely apposed, short, hair-like spines.

The 1st antenna reaches back to about the end of the furcal rami. The 8th and 9th segments are fused, but the 24th and 25th are separate. The proportional lengths of the segments are as follows :

Segments	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	76	50	23	23	27	29	30	49	25	27	27	50	50	51	48	50	49	58

20.	21.	22.	23.	24.	25.
54	43	59	47	40	15 = 1000

In the 2nd antenna the proportional lengths of the exopod and endopod are as 42 to 32. The proximal seta arising from the 2nd segment of the exopod springs from a raised papilla.

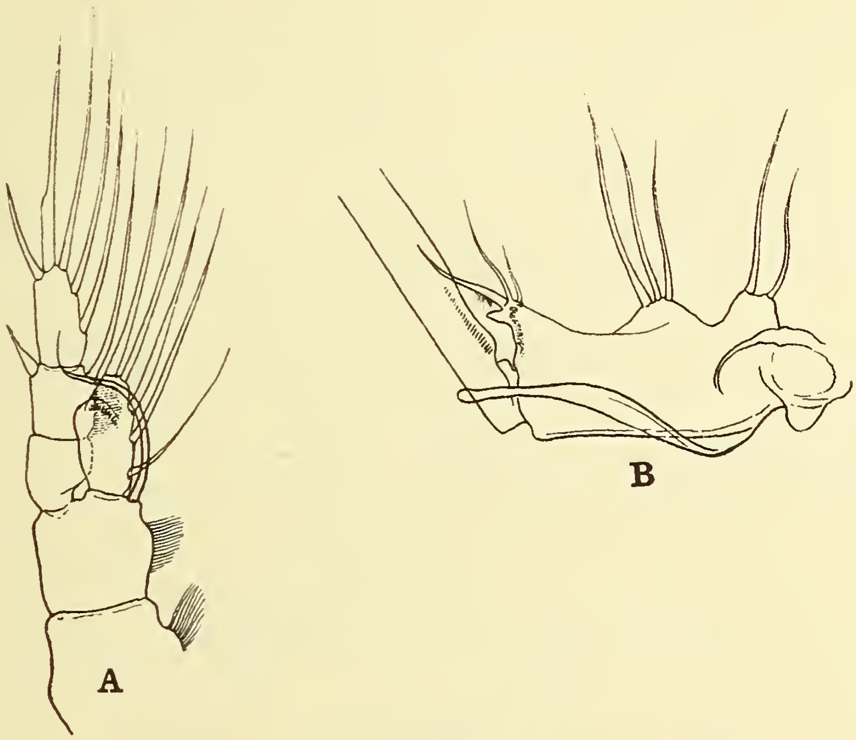
The mandible has the characteristic form of the genus; the biting ramus is very stout and is armed with strong teeth.

The 1st and 2nd maxillæ resemble those of other members of the genus.

The maxilliped differs from all other species in the genus in the great length of the free process of the lamella on the basal segment; this reaches to well beyond the distal margin of the segment, and is slightly expanded at the tip (Text-fig. 9, B).

In the 1st leg (Text-fig. 9, A) the exopod is composed of two free segments, the 1st and 2nd being only partially separated. Segment 1 is devoid of any marginal spine. The inner margins of both basal segments are fringed with a row of delicate hairs.

In the 2nd leg the endopod consists of two segments, but in the specimen dissected the division appeared to be incomplete. A gland opens to the surface at the base of the



Text-fig. 9.—*Gætanus brevicornis.* A, 1st leg. B, Basal portion of maxilliped.

marginal spine on the 1st and 2nd segments of the exopod and near the base of the 3rd marginal spine on the 3rd segment.

In the 3rd and 4th legs the endopod consists of three segments. As in the 2nd leg, a gland opens on the external border near the marginal spine of the 1st and 2nd segments of the exopod, and one near the base of the 3rd marginal spine of the 3rd segment. The 1st basal segment of the 4th leg bears the usual row of modified hairs, but these are delicate and hair-like, and are about thirteen in number.

Although the descriptions given by Esterly are quite inadequate, I have little doubt that his *ascendeus* and Wolfenden's *rectus* are the same, and that the present specimens are further examples of this rare species.

Distribution.—This species has been recorded from a depth of 2000 metres in the Tropical Atlantic Ocean (Wolfenden) and from the San Diego Region of the Pacific

(Esterly.) In the Indian Ocean it occurs in the Laccadive Sea (Sewell) and the Maldive area (present record) at some depth between 1500 and 366 metres.

Gætanus kruppi Giesbrecht. (Text-fig. 10, A–F.)

Gætanus kruppi, Giesbrecht, 1903, p. 202, pl. vii, fig. 8, pl. viii, fig. 29 ; van Breemen, 1908, p. 41, fig. 47 ; A. Scott, 1909, p. 48, pl. ix, figs. 9–15, ♀, pl. x, figs. 1–9, ♂ ; With, 1915, p. 97, fig. 25, and pl. iii, fig. 3 ; Sars, 1925, p. 61, pl. xviii, figs. 5–8 ; Wilson, 1932, p. 52, fig. 32.
Gætanus clarus, Esterly, 1906, p. 57, pl. ix, fig. 5, pl. xiv, fig. 90.
? *Gætanus major*, Wolfenden, 1904, p. 114, pl. ix, figs. 7 and 8, and 1911, p. 231.

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 4 females, adult, 1 juv. ; 5 young males.
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female, 1 male.
Sta. 172, Central part of Arabian Sea, 850–0 m., 63 females, adult, 3 juv. ; 1 male.
Sta. 186, Gulf of Aden, 575–0 m., 4 females, 1 juv. ; 1 male, juv. ; 600–0 m., 42 females, 1 male adult, 3 juv.

♂. Total length, 5·17 mm.

The proportional lengths of the cephalothorax and abdomen are as 75 to 25. The proportional lengths of the various segments are as follows :

Cephalon	Th. 1.	Th. 2.	Th. 3.	Th. 4. Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd 5.	Furca.
	540	71	65	75	42	74	48	42	10	32 = 1000

The body is more slender than in the female.

In the 1st antenna (Text-fig. 10, A) the segments have the following proportional lengths :

Segment	1.	2.	3.	4.	5.	6.	7.	8–10.	11.	12–13.	14.	15.	16.	17.	18.	19.	20–21.	22.
	77	41	24	26	30	33	37	81	22	50	28	50	52	54	55	63	96	63

23.	24–25.
63	55 = 1000

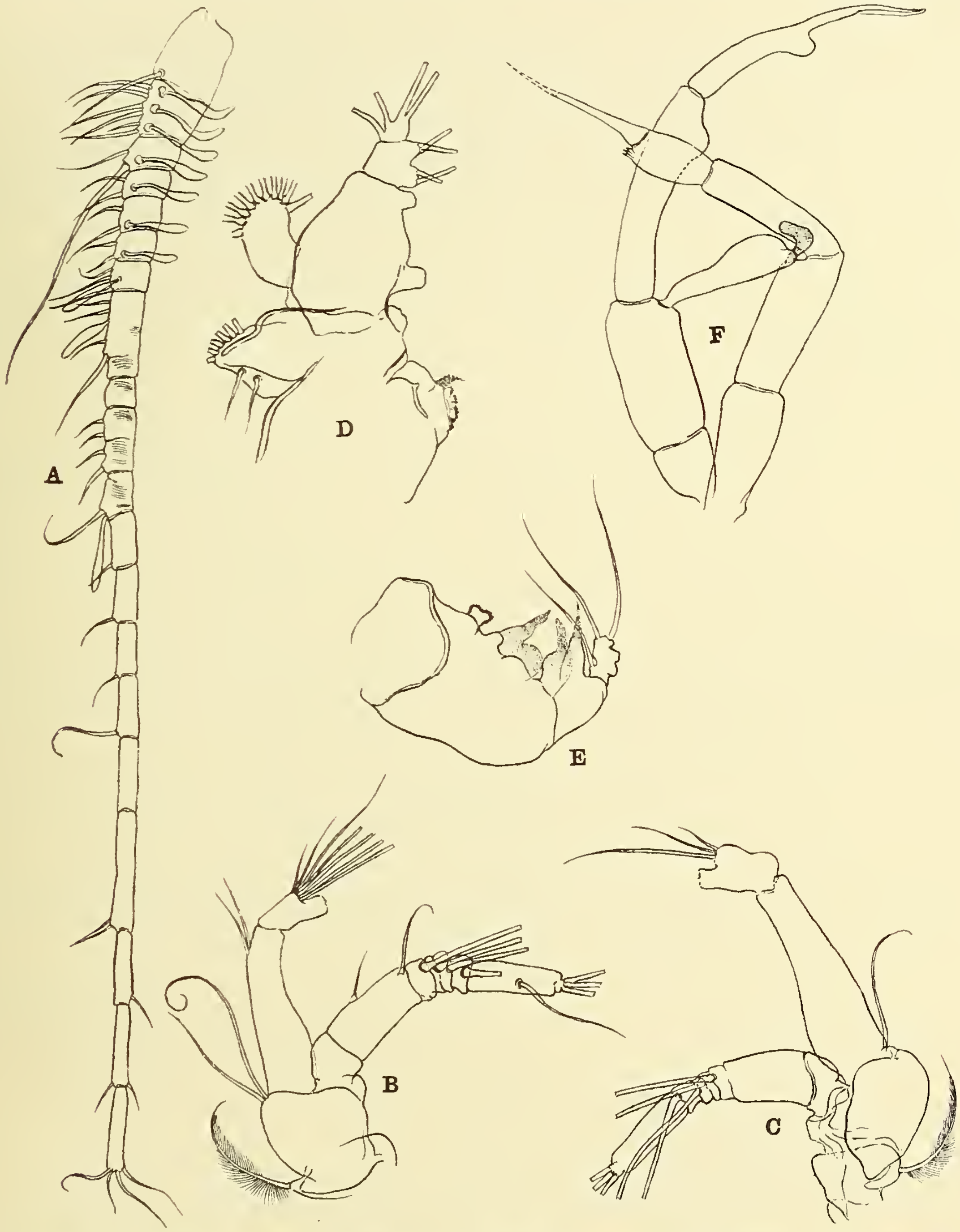
In the present specimen segments 8 and 9 are completely fused, and only a trace of the line of separation between segments 9 and 10 can be made out : segments 12 and 13 are fused, though a trace of the line of fusion can be seen : segments 20 and 21 are completely fused and so are segments 24 and 25.

The 2nd antenna (Text-fig. 10, C) differs from that of the female in that the two rami are nearly equal in length, whereas in the female the endopod is considerably the shorter. I have been unable to detect any seta on either the 2nd or the middle of the 7th segment.

The mouth parts (Text-fig. 10, D and E) are considerably reduced.

A comparison of the 5th pair of legs (Text-fig. 10, F) in the present specimen with the corresponding appendage of the form described by A. Scott (1909, pl. x, fig. 9) and of that described by With (1915, pl. iii, fig. 3 d, under the name *G. major*) reveals no marked difference, and certainly does not justify With in regarding the Malay form as being different from the Atlantic species.

Remarks.—As already mentioned, there is some doubt as to whether the form described by Wolfenden (1904) from the Faeroe Channel, and again recorded by him from the South Atlantic Ocean (1911) under the name *Gætanus major* is identical with *G. kruppi*



Text-fig. 10.—*Gætanus kruppi.* a, 1st antenna, male. b, 2nd antenna, female. c, 2nd antenna, male. d, 1st maxilla, male. e, 2nd maxilla, male. f, 5th pair of legs, male.

Giesbrecht ; in both his original account and again in his report on the collections of the "Gauss" Wolfenden asserts that in *G. major* there is no lamella on the basal segment of the maxilliped and, as Farran (1926, p. 249) points out, if this be confirmed, then these

two species are not identical. Wolfenden, to whom Farran submitted examples of a *Gætanus*, which were taken off Ireland, and in which a lamella was present, identified these as being examples of *G. major*, though they are identical with the form referred by With to *G. kruppi*.

Female examples of this species exhibit some variation in size. Giesbrecht's original specimens measured 3·6–4·0 mm. Wolfenden gives the length of his examples from the North Atlantic and Faroe Channel as "over 5 mm.," and of specimens in the "Gauss" collection from the tropical and southern Atlantic Ocean as from 5·0–5·6 mm.; Sars gives the length of specimens from the North Atlantic as 5·2 mm., and With's examples from the North Atlantic measured 5·4 mm. A. Scott's specimens from the Malay Archipelago measured as much as 5·7 mm. In the present collection the majority of specimens range from 4·8–5·0 mm., but a single example from Sta. 131 D measured 5·7 mm.

I was unable to detect any appreciable difference between this large form and the normal smaller specimens. The proportional lengths of the various segments of the body in the two forms were as follows:

	Cephalon and Th. seg. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
Small form	544	85	71	75	85	41	34	24	41 = 1000
Large ,,	536	85	74	79	91	40	32	23	40 = 1000

Similarly the segments of the 1st antenna showed corresponding proportional lengths:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Small form	65	45	24	26	29	32	34	50	26	27	29	49	47	50	50	50	50
Large ,,	67	49	23	24	28	30	31	51	25	27	28	52	50	51	49	50	50

19.	20.	21.	22.	23.	24.	25.
61	54	43	58	48	37	16 = 1000
59	52	43	54	48	38	15 = 1000

It seems probable that there is a correlation between the size of the individual and the depth, or, more probably, the temperature, at which it occurs:

Locality.	Depth.	Total length.
In the Mediterranean Sea . . .	1000–2600 m. .	3·6–4·0 mm.
,, Bay of Biscay	750–900 ,, .	4·45–4·8 ,,
,, North Temperate Atlantic . .	750 ,, .	4·7 ,,
,, Tropical Indian Ocean . . .	850 ,, .	4·8–5·0 ,,
,, North Temperate Atlantic . .	5000–0 ,, .	5·0–5·6 ,,
,, Tropical Indian Ocean . . .	1500 ,, .	5·7 ,,
,, Malay Archipelago . . .	750–1500 ,, .	5·7 ,,

Distribution.—In the Pacific Ocean in the San Diego region (Esterly) and the Malay Archipelago (A. Scott). In the Indian Ocean in the Laccadive Sea (Sewell) and the Arabian Sea (present record). In the Atlantic Ocean in the North Temperate region (Sars, Rose), off the American coast, south of Nantucket (Wilson), to the south of Davis

Strait (Jespersen), in the Bay of Biscay and the west coast of Ireland (Farran), and in the Mediterranean Sea (Giesbrecht).

The vertical range of this species appears to extend down to depths as great as 2000 metres or more but, as Farran remarks, it never approaches the surface.

Group III.

Gœtanus antarcticus Wolfenden. (Text-fig. 11, A–F.)

Gœtanus antarcticus, Wolfenden, 1905, p. 4, pl. iii, fig. 1; Wolfenden 1908, p. 30, pl. iii, fig. 6; Wolfenden, 1911, p. 229; Farran, 1929, p. 233.
[non *Gœtanus antarcticus*, Brady, 1918, p. 19, pl. iii, figs. 1–6 and 19.]

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 2 females, 2 immature males.

Sta. 76, Gulf of Oman, 2500 m., 1 female.

Descriptive Notes.—♀. Total length, 7·6–8·25 mm.

The proportional lengths of the anterior and posterior regions of the body (Text-fig. 11, A) are as 80 to 20.

The segments of the abdomen have the following proportional lengths:

Segment 1–2.	3.	4.	5.	Furca.
37	19	17	11	16 = 100

The genital and the two following segments are each provided with a row of spines, that runs parallel to and a short distance in front of the posterior margin; this row is composed of stout triangular spines across the dorsal aspect, but on the sides and below the size of the spines is much reduced, and the row consists of minute spinules with scattered larger ones at short intervals. The genital segment is markedly produced ventrally. A tuft of hairs arises from the ventral aspect of the anal segment and from the furcal rami.

The 1st antenna is composed of twenty-four free segments; segments 8 and 9 are fused together. Wolfenden (1905, p. 7) states that there are twenty-three segments, but he figures segments 24 and 25 as being fused, whereas in the present examples they are separate. The proportional lengths of the segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	80	43	25	25	25	27	29	50	23	25	25	47	43	52	50	52	52	64

20.	21.	22.	23.	24.	25.
60	45	60	52	34	12 = 1000

The 2nd–11th segments are each furnished with a transverse row of hairs running across the posterior aspect near to and parallel with the distal margin.

In the 2nd antenna (Text-fig. 11, B) the endopod is very much " more than half as long " as the exopod; the actual measurements in the present specimen are as 63 to 70. The 1st basal segment is furnished with a tuft of fine setæ on its inner aspect.

In the maxilliped (Text-fig. 11, D) the lamella on the 1st basal segment is rounded at its distal end and is not produced in a hook-like process.

In the swimming legs (Text-fig. 11, E and F) there are tufts of fine hairs on the anterior aspect of the distal segment of the endopod. Secretory glands are present on all three segments of the exopod of the 2nd–4th legs, and these open by pores situated close to the base of the marginal spine at the distal external angle.

TEXT-FIG. 11.—*Gætanus antarticus.* A, Female, lateral view. B, 2nd antenna. C, 1st maxilla. D, Maxilliped, basal segment. E, 1st leg. F, 4th leg.

Distribution.—Up to the present time this species has been taken only in the Antarctic region: it was originally caught at the edge of the pack-ice in lat. 64° 18′ S.; long. 80° 27′ E. from 2000 metres depth by the "Gauss," and in Macmurdo Bay in about lat. 77° S., long. 165° E. under the ice by the "Discovery." Farran records it in the "Terra Nova" collections from about lat. 71° 41′ S., long. 170° W. Its occurrence in the deep water at the northern end of the Arabian Sea and in the Gulf of Oman is therefore somewhat surprising. Presumably it has been carried northward in the Antarctic Bottom Drift or the intermediate current.

Gætanus curvicornis Sars. (Text-fig. 12, a–e.)

Gætanus curvicornis, Sars, 1925, p. 55, pl. xvii, fig. 2; Jespersen, 1934, p. 61.

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 2 females.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Descriptive Notes.—♀. Total length, 3·75 mm.

The proportional lengths of the anterior and posterior regions of the body are as 75 to 25. In its general appearance this species closely resembles *Gætanus minor* Farran; the anterior horn in two of these specimens was curved downwards; in the third, however, it appeared to have been damaged at the base, and projected straight forwards; in all three specimens it is continued back in a low crest on the dorsal aspect. The proportional lengths of the segments of the body are as follows:

Cephalon & Th. 1.	Th. 2.	3.	4–5.	Abd. 1–2.	3.	4.	5.	Furca.
523	72	64	110	85	38	38	30	38 = 1000

The line of fusion of the cephalon and the 1st thoracic segment is clearly visible across the dorsal aspect. The spines on the 5th thoracic segment are long and slender, and reach back for about three-fourths the length of the genital segment. The genital segment of the abdomen is almost as deep as long, and is swollen ventrally. The posterior margins of the abdominal segments are devoid of any row of spines. The furcal rami are about two-thirds as wide as long, and are directed straight backwards; they are not divergent.

The 1st antenna over-reaches the posterior end of the body by about the last three segments; the proportional lengths of the segment are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	67	43	19	19	21	24	24	42	23	25	28	52	48	48	48	49	50	62

20.	21.	22.	23.	24.	25.
62	50	62	54	62	18 = 1000

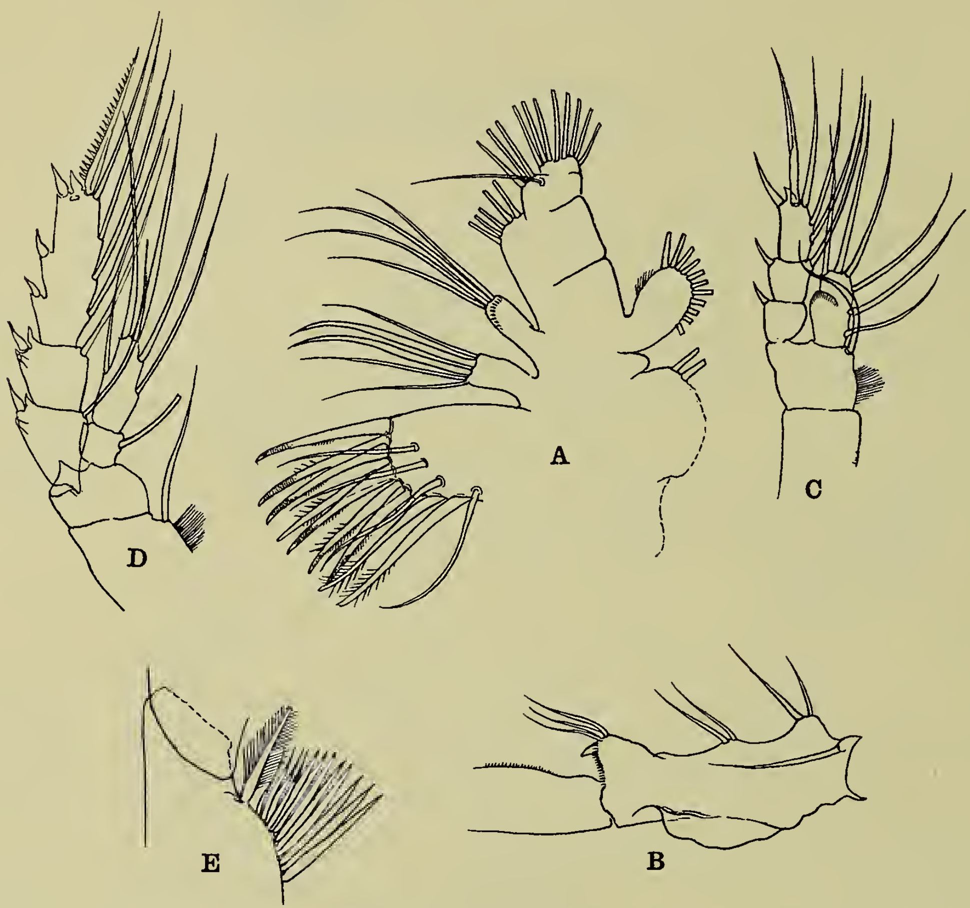
The 8th and 9th segments are fused, but the 24th and 25th are clearly separate.

In the 2nd antenna the exopod is about one-and-a-quarter times the length of the endopod. In the 2nd segment of the exopod both the first two setæ arise from small projections on the anterior aspect of the segment, as in *G. antarcticus*.

The mandible and 1st (Text-fig. 12, a) and 2nd maxillæ resemble those of other members of the genus.

The maxilliped (Text-fig. 12, B) is provided with a lamella on the 1st basal segment; this lamella resembles that of *Gœtanus antarcticus* Wolfenden and *G. latifrons* Sars in being crest-like and having no hook-like process.

In the 1st leg (Text-fig. 12, C) the exopod is composed of three segments, each of which bears a marginal spine; that on the 1st segment is somewhat delicate, and is smaller than those on either the 2nd and 3rd segments, and that on the 3rd segment is about twice the length of that on the 2nd.



Text-fig. 12.—*Gœtanus curvicornis* Sars, ♀. A, 1st maxilla. B, Basal segment of maxilliped. C, 1st leg. D, 2nd leg. E, Basal segment of 4th leg.

In the 2nd leg (Text-fig. 12, D) the endopod is composed of two segments. A gland opens on the surface on each of the three segments of the exopod; in the 1st and 2nd segments the aperture is on the outer border, close to and immediately proximal to the marginal spine; on the 3rd segment it opens close to the base of the 3rd marginal spine.

In the 3rd and 4th legs the endopod is composed of three segments.

The 2nd basal segment of the 4th leg (Text-fig. 12, E) bears the usual row of modified hairs; in all there appear to be about twelve that increase in size towards the proximal end of the row.

Distribution.—This species has now been reported from the North Atlantic in the neighbourhood of the Azores, and between these islands and the coast of Portugal (Sars) and from the northern part of Baffin Bay to the west of Greenland (Jespersen); the present record extends the range to the Arabian Sea.

Gætanus latifrons Sars.

Gætanus latifrons, Sars, 1905, p. 11 ; van Breemen, 1908, p. 39, fig. 43 ; A. Scott, 1909, p. 49, pl. x, figs. 10–17 ; Sars, 1925, p. 57, pl. xvii, figs. 7–9 ; Rose, 1929, p. 18, pl. i, fig. 2; Sewell, 1929, p. 102.
Gætanus holti, Farran, 1905, p. 33, pl. vi, figs. 1, 12.
Gætanus longispinus, Wolfenden, 1905, p. 7, pl. iii.

Occurrence.—Sta. 145 D, Maldive Area, 500–0 m., vertical, 1 juv.

Distribution.—In the Pacific Ocean this species has, up to the present, been taken only in the Malay Archipelago (A. Scott). It has been taken in the Indian Ocean in the Bay of Bengal and Laccadive Sea (Sewell), and in the Maldive area (present record). In the Atlantic Ocean it occurs in the " Gauss " collection (Wolfenden), in large numbers to the south of the Canary Islands (Sars), and in the Bay of Biscay (Rose) ; it is common off the west coast of Ireland (Farran), and has been taken as far north as 65° N. off the east coast of Greenland (With).

As regards its depth distribution, this species appears to inhabit depths ranging off Ireland from 600 to 2100 metres ; in the North Atlantic it has been taken at depths of approximately 600 to 1000 metres. In the Indian Ocean it occurs at depths of 366 to 732 metres, and the single specimen taken in the Malay Archipelago by the " Siboga " was in a haul from 750 to 0 metres.

Genus *Euchirella* Giesbrecht.

A number of species have been placed in this genus by different authors, but Sars (1920) has removed several to his new genus *Pseudochirella*, and the species that now remain in *Euchirella* are as follows :

Euchirella amœna Giesbrecht.
E. bella Giesbrecht.
E. bitumida With.
E. brevis Sars.
E. curticauda Giesbrecht.
E. galeata Giesbrecht.
E. gracilis Esterly.
E. intermedia With.
E. latirostris Farran.
E. maxima Wolfenden.
E. messinensis (Claus).
E. orientalis Sewell.
E. plumosa Brady.
E. propria Esterly.
E. pulchra (Lubbock).
E. rostrata (Claus).
E. rostromagna Wolfenden.
E. similis Wolfenden.
E. simplex Esterly.
E. truncata Esterly.

Of these some seem to me to be synonymous ; thus *Euchirella truncata* Esterly, *E. gracilis* Wolfenden and *E. intermedia* With are in all probability synonyms ; and, similarly, *E.*

galeata Giesbrecht and *E. bitumida* With probably only represent respectively the Pacific and Atlantic forms of the same species. *Euchirella tumida*, very imperfectly described and figured by Brady (1918, p. 20), is probably a synonym of *Scolecithrix danœ* (Lubb.).

It is probable that in the near future these species will have to be separated into two groups, in which the structure of the 5th pair of legs in the male is different. Up to the present time the males of some species are still unknown, but among those that have been described we can distinguish two distinct types, as follows :

" Messinensis " Type.	" Curticauda " Type.
The 2nd basal segment of the left leg reaches, at most, only as far as the distal end of basal I of the right leg.	The 2nd basal segment of the left leg reaches well beyond the distal end of basal II of the right leg.
The endopod of the left leg is extremely short or may be absent altogether.	The endopod of the left leg is a long cylindrical segment that is at least half the length of the 1st segment of the exopod.
The endopod of the right leg is long and reaches as far as the end of the exopod so as to form a pair of pincers.	The endopod of the right leg is comparatively short and only reaches as far as the end of the proximal segment of the exopod, and in consequence a pair of pincers is absent.

In the " Messinensis " Group can be placed *Euchirella messinensis*, *E. bella*, *E. truncata*, *E. orientalis*, *E. propria* and *E. pulchra*, while *E. amœna* would also seem to belong to this group, though the structure of the left leg differs slightly in this species from that of the others, since the three segments of the exopod of the left leg are inserted distally to each other, whereas in all the other species the third segment is inserted a little proximally to the end of the 2nd segment, so as to form a small pair of pincers.

In the " Curticauda " Group can be placed *Euchirella curticauda*, *E. maxima*, *E. rostrata* and *E. rostromagna* : in this group the type of 5th leg approximates to that present in males of *Chirundina* and *Pseudochirella*.

It seems probable that a second difference between these two groups is to be found in the character of the exopod of the 1st leg. In the males of *Euchirella curticauda*, *rostrata* and *maxima*, the 1st and 2nd segments of the exopod of this leg are furnished with a marginal spine that is moderately, or even well, developed ; in the males of *Euchirella bella*, *messinensis*, *orientalis*, *pulchra* and *venusta* the portion of the exopod that corresponds to segment 1 is totally devoid of any marginal spine, and on segment 2 there is either no spine at all or only a very small and rudimentary one.

In the females of the " messinensis " group the basal segment of the 4th leg is armed with a row of spines ; in those of the " curticauda " group the corresponding projections have the character of flat plates, in several species definitely triangular in shape, as in *Euchirella rostrata*, *rostromagna* and *latirostris*.

"Messinensis" Group.

Euchirella bella Giesbrecht. (Text-fig. 13, A–F.)

Euchirella bella, Giesbrecht, p. 232, pl. xv, fig. 26; Sewell, 1929, p. 109.
Euchirella bella var. *indica*, Wolfenden, 1906, p. 1006, pl. xcvi, figs. 17–20.
Euchirella hessei (*non* Brady), A. Scott, 1909, p. 54.
Euchirella rostrata (*non* Claus), Thompson and A. Scott, 1903, p. 244.

Occurrence:

Sta. 61 A, Northern part of Arabian Sea, 500–0 m., 1 female; 1000–0 m., 1 female; 1500–0 m., 8 females.
Sta. 61 C, Northern part of Arabian Sea, 1000–0 m., 14 females, 1 male, 4 juv.; 1500–0 m., 3 females.
Sta. 76, Gulf of Oman, 1500–0 m., 2 females.
Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female, 1 male.
Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., vertical haul, 1 female.
Sta. 145 C, Maldive area, 500–0 m. vertical haul, 1 female.
Sta. 145 D, Maldive area, 100–0 m. vertical haul, 2 females; 500–0 m. vertical haul, 1 female adult, 1 female juv., 1 male, juv.
Sta. 172, Central part of Arabian Sea 200–0 m. 1 female.
Sta. 186, Gulf of Aden, 250–0 m., 4 females.

♀. Total length, 3·68 to 3·86 mm. This agrees closely with the measurements given by Giesbrecht, 3·8 mm., and by Wolfenden, 3·5 mm. As in other species, it seems probable that there is an increase in size with depth, for of the examples taken at Sta. 61, in the Arabian Sea, those from a depth of 500 metres measures on the average 3·68 mm., while those from 1000–1500 metres were on the average 3·75 mm.

The proportional lengths of the cephalothorax and abdomen are as 78 to 22. The proportional lengths of the various segments are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
389	146	88	79	88	92	36	29	13	40 = 1000

The cephalon and 1st thoracic segment are fused, but the line of fusion is clearly visible across the dorsal aspect. The rostrum is slightly depressed and is directed downwards. The posterior thoracic margin is rounded. The genital segment of the abdomen is swollen ventrally. The posterior margins of the genital and 3rd segments are fringed on the dorsal aspect with a series of weak spines, that appear to have been produced by the splitting of the chitinous margin. In the 4th segment these spines are stronger. The 5th or anal abdominal segment is very short and is telescoped into the 4th, and bears a tuft of hairs on the ventral aspect.

The 1st antenna is composed of 23 free joints, segments 8 and 9, and 24 and 25 respectively being fused; it reaches back to about the middle of the abdomen. The proportional lengths of the segments are as follows:

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
62	48	25	24	24	24	24	40	26	28	29	44	46	62	62	63	62	62

20.	21.	22.	23.	24–25.
56	48	46	41	54 = 1000

A. Scott (1909, p. 54) has pointed out that the spines on the 2nd basal segment of the 4th leg may vary from 3 to 4, and in rare cases even 5 may be present : this variation may even occur in a single specimen, for in one example dissected there were three spines on one side and five on the other.

TEXT-FIG. 13.—*Euchirella bella* Giesbrecht. A, 1st maxilla, female. B, 1st maxilla, male. C, 2nd maxilla, male. D, 1st leg, male. E, 5th pair of legs, male. F, Terminal claw of left 5th leg, male.

Associated with the females in this collection were two examples of a mature male, which I have no doubt belong to this species.

♂. Total length 3·50 mm.

The proportional lengths of the cephalothorax and abdomen are as 73 to 27.

The proportional lengths of the various segments of the body are as follows :

Cephalon & Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.	
462	90	80	104	75	52	47	47	14	28	= 1000

The forehead is rounded, without a crest, and the rostrum is depressed. The posterior thoracic margin is rounded.

The abdomen is composed of five segments, of which the 5th is almost completely telescoped into the 4th. The 2nd, 3rd and 4th segments of the abdomen are provided along their posterior margins with a row of triangular spines. The anal segment bears a tuft of hairs ventrally.

The 1st antenna reaches back to about the middle of the abdomen ; certain segments are fused together, but this fusion differs on the two sides ; on the left side, segments 8 and 9 are fused together and segment 10 is, partially at least, fused with 9 ; segments 12 and 13 and 24 and 25 respectively are also fused together ; on the right side, in addition to the above, segments 20 and 21 are fused.

The proportional lengths of the segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12–13.	14.	15.	16.	17.	18.	19.
Right	67	51	23	22	24	22	26	59		22	69	46	63	60	67	58	64
Left	66	51	26	23	26	23	26	36	21	26	65	48	58	60	63	59	64

	20.	21.	22.	23.	24–25.	
Right	105		51	45	51	= 1000
Left	58	51	51	49	50	= 1000

In the 2nd antenna the endopod is about half the length of the exopod.

The mandible is reduced and the biting ramus is entirely absent.

The 1st maxilla (Text-fig. 13, B) is also reduced and is very similar to that of *E. messinensis*, as figured by Giesbrecht (1902, pl. xv, fig. 17). The inner lobes are entirely absent, and the 2nd basal segment and small endopod are fused, and the latter is rounded distally and bears three setæ ; the exopod is well formed and bears 10 setæ, and the outer lobe bears six.

The 2nd maxilla (Text-fig. 13, C) is reduced to a small, only partially segmented, process.

The maxilliped is moderately well developed.

In the 1st leg (Text-fig. 13, D) the exopod is composed of two segments, of which the proximal is devoid of any marginal spines : two glands appear to open on the external margin, one near the middle of the segment and the second at the distal outer angle. The distal segment of the exopod bears a stout marginal spine at the distal outer angle. The endopod consists of a single segment, and the outer margin is produced in a rounded swelling that bears a row of needle-like spinules.

The 2nd, 3rd and 4th legs resemble those of the female.

The 5th pair of legs (Text-fig. 13, E, F) closely resemble those of *Euchirella messinensis* Giesbrecht, *E. pulchra* (Lubbock), *E. propria* Esterly, *E. orientalis* Sewell and *E. intermedia* With.

Distribution.—This species appears to be confined to the Indo-Pacific region. It has been recorded from the west coast of S. America (Giesbrecht), the Malay Archipelago (A. Scott), the Bay of Bengal (Sewell), the Laccadive Sea (as *rostrata*, Thompson and A. Scott), the Maldive Archipelago (Wolfenden) and the Arabian Sea (present records).

Euchirella galeata Giesbrecht. (Text-fig. 14, a–f.)

Euchirella galeata, Giesbrecht, 1892, p. 233, pl. xv, fig. 18, pl. xxxvi, figs. 25, 26; Sewell, 1929, p. 110, fig. 41, *a–e*; Esterly, 1905, p. 115, fig. 22.

? *Euchirella bitumida*, With, 1911, p. 131, fig. 34, pl. v, fig. 9, *a–g*, pl. viii, fig. 4, *a–e*; Sars, 1925, p. 74, pl. xxi, figs. 15–18.

Occurrence:

Sta. 96, Central part of Arabian Sea, 645–400 m., 22 females, adult; 21 females, juv.; 12 males, juv.

Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., 1 female.

Sta. 145 C, Maldive area, 50–0 m., 1 female, juv.

Sta. 145 D, Maldive area, 500–0 m., 2 females, adult.

Sta. 172, Central part of Arabian Sea, 400–0 m., 62 females, adult, 22 juv.; 850–0 m., 38 females, 5 juv.

Sta. 186, Gulf of Aden, 600–0 m., 10 females, adult, 2 juv.

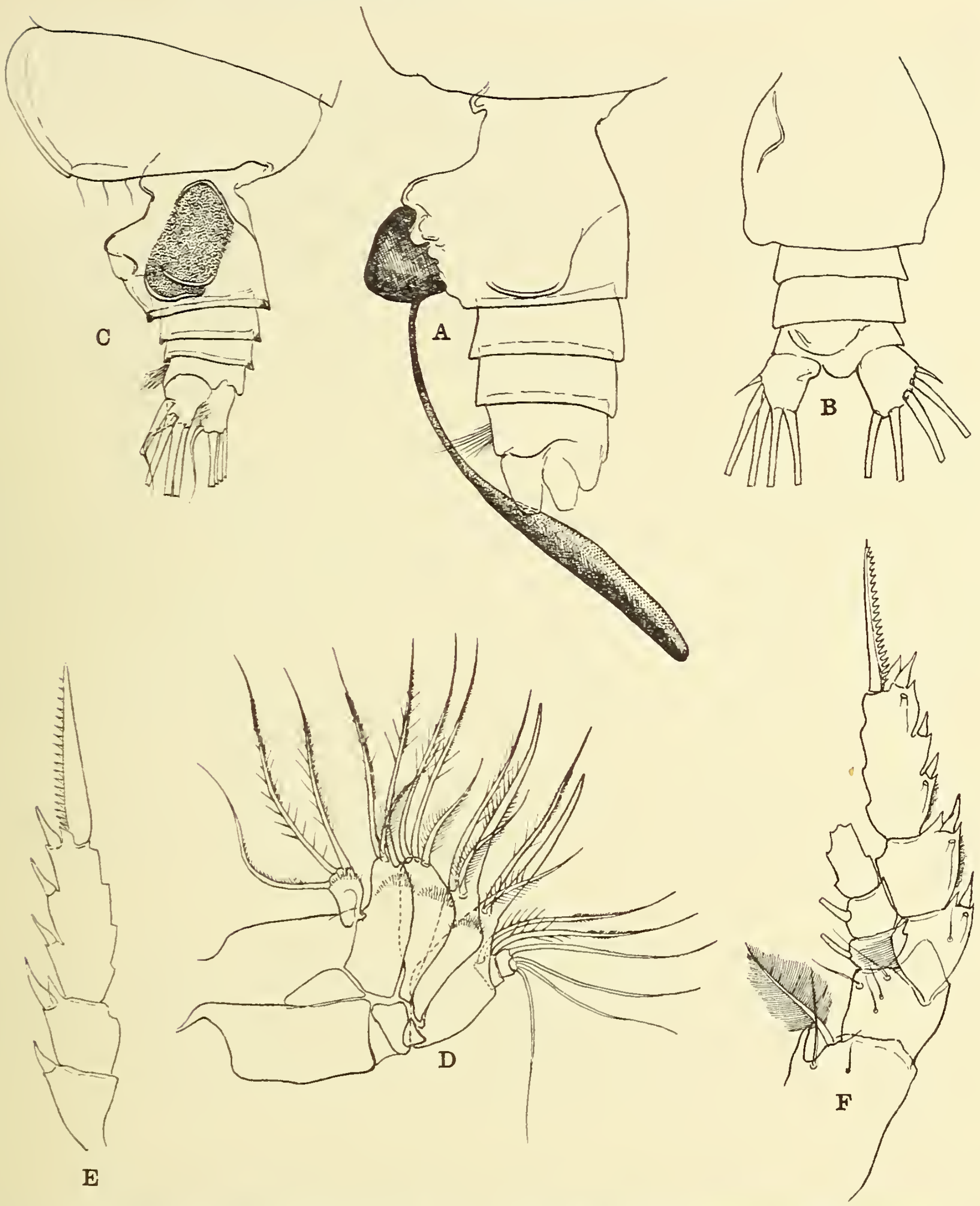
Descriptive Notes.—♀. Total length, 6·10 mm. Giesbrecht's original specimen and those taken by Esterly, from the west coast of America were somewhat larger than this, measuring 6·4 and 6·5 mm.

The proportional lengths of the anterior and posterior regions of the body are in the present specimens as 4·2 to 1; Giesbrecht gives the proportions in his example as 5 to 1·4, which is equivalent to 3·57 to 1.

The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 2.	Abd. 4.	Abd. 5.	Furca.
368	150	95	89	85	95	34	29	26	29 = 1000

The cephalon and 1st thoracic segment are fused, but in stained specimens a clear line of fusion, deeply stained, can be seen right across the lateral and dorsal aspects. The posterior thoracic margin is rounded, but just above the ventro-lateral point there is a small emargination, that presumably marks the fusion of the 4th and 5th segments. In the abdomen (Text-fig. 14, a–c) the genital segment is large, being one-and-a-half times the length of the next two segments together; when viewed from the dorsal aspect the left side is more prominent than the right (*vide* Sewell, 1929, p. 111, fig. 41, *a*), but if the animal be slightly rotated over towards the left, the right side of the segment presents a swelling, the form of which agrees closely with the figure given by With for this segment in *Euchirella bitumida* (*vide* With, 1915, pl. v, fig. 9, *a*). When viewed from the side there is a sharp ridge across the anterior region of the segment ventrally and posteriorly to this the margin rises up to a ridge that runs across the segment immediately in front of the genital aperture; from this point the margin slopes backwards and upwards to the posterior border; above the genital aperture and occupying the greater part of the left side is a swelling that stains deeply and is edged above by a chitinous thickening, while a second similar thickening marks the posterior border of the swelling.



Text-fig. 14.—*Euchirella galeata* Giesbrecht, ♀. a, Abdomen from the left side, with spermatophore attached. b, Abdomen, from above and slightly tilted to the left. c, Abdomen, from the left side. d, 2nd maxilla. e, Exopod of 2nd leg. f, 4th leg.

The 1st antenna reaches back to a little beyond the posterior margin of the genital segment. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	66	45	22	21	24	23	23	40	30	32	29	47	45	66	65	73	69	64

20.	21.	22.	23.	24–25.	
53	43	41	36	43	= 1000

As in *E. bitumida* With, the 17th segment is the longest.

In the 2nd antenna the proportional lengths of the two rami are as 18 to 59, the endopod thus being a little less than one-third the length of the exopod; the two lobes of the 2nd joint of the endopod each bear 6 setæ, the two innermost on the inner lobe being smaller and more delicate than the others.

The mandible is strong, and the biting ramus is provided with stout teeth.

The 1st maxilla bears 13 spines on the 1st inner lobe, 4 on the 2nd and 3 on the 3rd, the two outer ones being small and delicate and the middle one stout. The 2nd basal segment bears 2 small and 1 large setæ, and the endopod 4. The exopod bears 11 setæ, of which the first two are smaller than the others; With (*loc. cit.*, p. 131) states that in *E. bitumida* the 5th is also small, but that is not the case in the present specimen. The outer lobe bears 6 large and 2 small setæ.

The 2nd maxilla (Text-fig. 14, D) closely resembles that of *E. truncata* Esterly and *E. bitumida* With.

In the maxilliped the proportional lengths of the two basal segments are as 42 to 47 and the endopod is 24; the outer border of the 2nd basal segment is slightly sinuous. With remarks that in *E. bitumida* "the Ri II has only 3 setæ"; this is the condition in *E. galeata*, and in all the other species that I have so far examined, namely *bella*, *rostrata*, *pulchra*, *venusta*, *orientalis* and *truncata*.

In the 1st leg the fusion of segments 1 and 2 of the exopod is complete and I could not detect any trace of the line of fusion.

In the 2nd leg (Text-fig. 14, E) the marginal spine on segment 2 of the exopod reaches to the base of the 1st spine on segment 3.

In the 4th leg (Text-fig. 14, F) the 1st basal segment bears a single spine that is moderately stout and reaches as far as the distal end of the segment. In some specimens the spine was broken, but in no case was more than one spine present, and the two sides were symmetrical.

Remarks.—As I have previously pointed out (Sewell, 1929, p. 110), Farran considers that *E. bitumida* With is the Atlantic representative of *E. galeata*, which he considers to be a Pacific form; I am of the opinion that, in all probability, they are the same species, and that such slight differences as may be present in the character of the genital segment, on which the distinction is based, should only be regarded as of varietal value and are not truly specific.

Distribution.—The form *galeata* has been recorded from west coast of South America (Giesbrecht), the San Diego region (Esterly), the Malay Archipelago (A. Scott), the Bay of Bengal and the Laccadive Sea (Sewell), the Arabian Sea and the Gulf of Aden (present records), the South Atlantic Ocean (Wolfenden) and the North Atlantic (Lysholm and Nordgaard); the form *bitumida* has been recorded from the North Atlantic by Sars, With and Farran.

Euchirella orientalis Sewell. (Text-fig. 15, B–H.)

Euchirella orientalis, ♀, Sewell, 1929, p. 115, fig. 44.

Occurrence:

Sta. 61 C, Northern part of Arabian Sea, surface, 2 males.

Sta. 96, Central part of Arabian Sea, 645–400 m., 40 females, adult, 4 females, juv.; 2 males, adult, 1 male, juv.

Sta. 145 C, Maldive area, 500–0 m. vertical, 1 female adult.

Sta. 172, Central part of Arabian Sea, 200–0 m., 1 female, adult; 400–0 m., 23 males, 82 females; 850–0 m., 61 females, 16 males.

Sta. 186, Gulf of Aden, 575–0 m., 23 females, adult; 2 males, adult, 3 juv.; 600–0 m., 62 females, adult, 5 males.

Descriptive Notes.—♀. The total length ranges from 4·33 to 4·40 mm. The proportional lengths of the cephalothorax and abdomen are as 80 to 20. The proportional lengths of the various segments are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
360	181	87	82	82	102	26	23	23	34 = 1000

There is no frontal crest, and the rostrum is depressed and is directed vertically downwards. The cephalon and 1st thoracic segment are only partially fused. The posterior thoracic margin is rounded. In the abdomen (Text-fig. 15, c) the genital segment is nearly symmetrical and there is no prominent swelling on the left side. The dorsal aspect is produced in a swelling, and there is a moderate swelling ventrally around the genital aperture. The posterior margins of the first two segments are fringed dorsally with a row of spinules, and a tuft of hairs arises from the ventral aspect of the anal segment.

The 1st antenna reaches back to about the middle of the abdomen. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	57	46	21	24	24	24	23	44	28	31	31	43	46	66	61	66	60	65

20.	21.	22.	23.	24–25.
56	46	47	39	52 = 1000

In my original account of this species I gave the length of the first two segments together as 343 parts in 1000; this is an obvious error, and the figure should be 96.

In the maxilliped (Text-fig. 15, d) the proportional lengths of the two basal segments are as 41 to 59. The posterior margin exhibits two low prominences in the proximal half of the segment.

In the 4th leg (Text-fig. 15, f) the 1st basal segment usually bears two spines that are subequal and reach as far as the distal end of the segment.

Associated with the females at Stas. 96 and 172 were a number of adult males, that are, I think, the true male of this species.

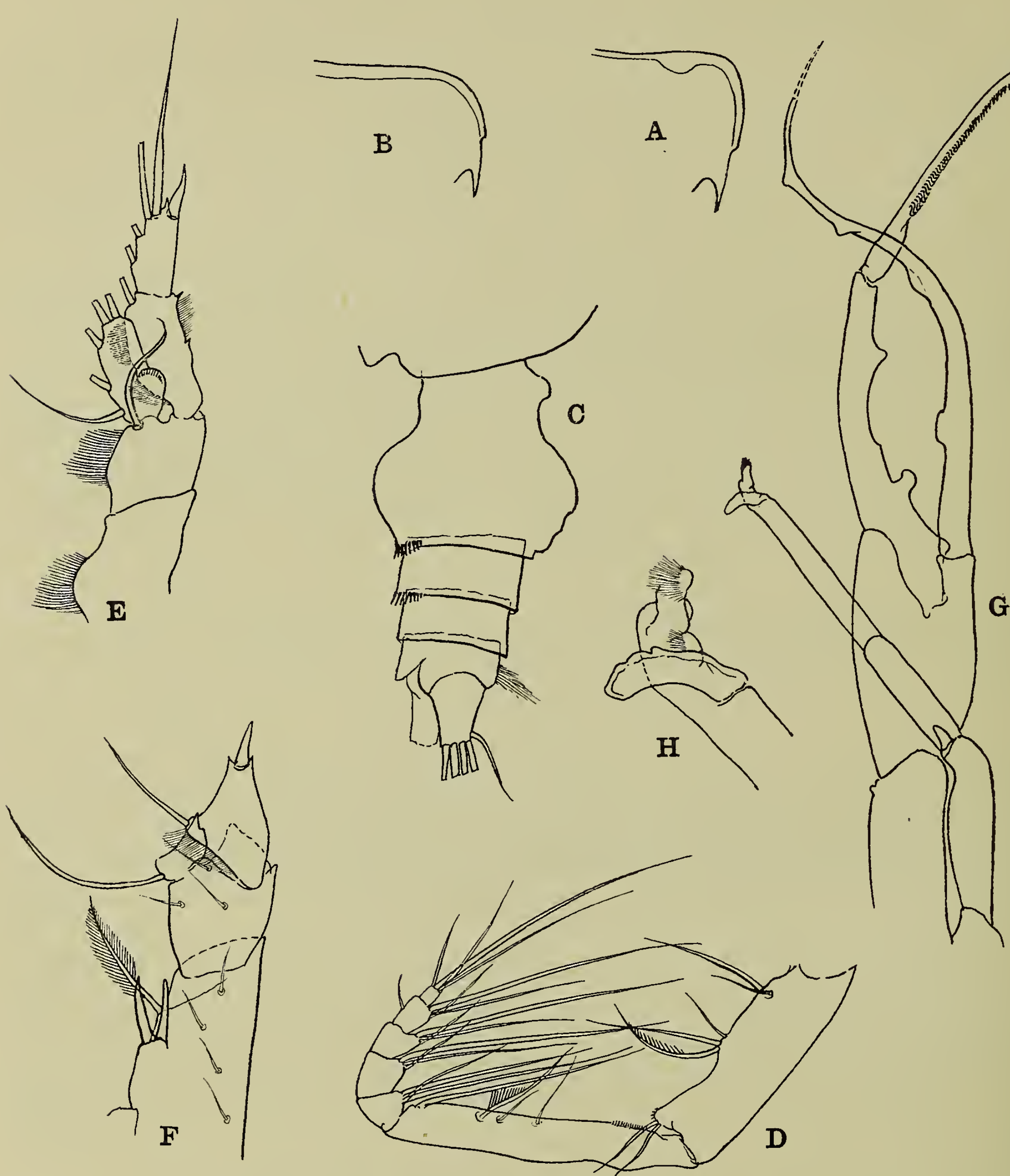
♂. Total length 4·77 mm. These specimens are thus somewhat larger than the females taken at the same stations, but very slightly smaller than the female *orientalis* taken in the Bay of Bengal, that had a length measurement of 4·8 mm.

The proportional lengths of the various segments of the body are as follows:

Cephalon & Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
470	81	81	97	75	56	53	47	6	31 = 1000

The body is considerably more slender than in the female. The forehead (Text-fig. 15, b) is provided with a crest, that very closely resembles that of *E. messinensis* Giesbrecht

(Text-fig. 15, A), but is not so elevated. The rostrum is depressed and is directed vertically downwards. The cephalon and 1st thoracic segment are completely fused. The posterior



Text-fig. 15.—A, *Euchirella messinensis* (Claus), ♂, head, lateral view. B, *Euchirella orientalis* Sewell, ♂, head, lateral view. C, ♀, abdomen, lateral view. D, ♀ Maxilliped. E, ♂, 1st leg. F, ♀, 4th leg. G, ♂, 5th pair of legs. H, ♂, Terminal claw of left 5th leg.

margin of the thorax is rounded. The 2nd and 3rd abdominal segments are fringed along their posterior margins with a row of triangular spinules. The anal segment is very short and is completely telescoped into the 4th segment; it bears ventrally a tuft of hairs.

The 1st antenna reaches back to a little beyond the middle of the 2nd abdominal segment. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9–10.	11.	12–13.	14–15.	16.	17.	18.	19.
Right	61	41	21	21	21	23	24	69	31	75	48 + 66	65	73	63	65
Left	59	41	20	21	21	23	24	69	31	76	48 + 65	66	73	63	65

Segment	20–21.		22.	23.	24–25.	
Right	95		50	42	45	= 1000
Left	53	45	50	42	46	= 1000

In the left antennule segments 8, 9 and 10 are fused, and so are segments 12 and 13, 14 and 15, and 24 and 25 ; in the right antennule segments 20 and 21 are also fused.

In the 2nd antenna the endopod is well developed, the proportional lengths of the two rami being as 27 to 38.

As in the other males of this genus the mouth parts are reduced, especially the mandible, which lacks a biting ramus ; the 1st inner lobe of the 1st maxilla is also wanting, and the 2nd maxilla is reduced to a fleshy process, with a single segment at the distal end.

The proportional lengths of the two basal segments of the maxilliped are as 32 to 47.

The 1st leg (Text-fig. 15, E) is of the usual type, the exopod consisting of two segments only, and the endopod of one ; the proportional lengths of the parts of the exopod are : segment 1–2, 73, segment 3, 54, end-spine 31. There is a very minute spine on the outer margin of the combined 1st and 2nd segment of the exopod, at the distal outer angle of each part ; the outer border between these two small spinules is fringed with hairs.

In the 2nd leg the two rami have the usual form, the endopod being composed of a single segment. With has called attention to the presence of an increased number of teeth in the end-spine of this leg, when compared with the more posterior appendages, in *E. messinensis*, which he states is " about 50 instead of 25 teeth " ; in the present species the number is 33 instead of 20 as in the 3rd and 4th legs.

The 5th pair of legs (Text-fig. 15, G, H) is of the same type as that found in *E. messinensis*, *pulchra*, *venusta*, *bella* and *amœna*. The endopod of the right leg is of approximately the same length as the two basal segments together. The 2nd basal of the left leg is slightly longer than in *E. venusta* and much longer than in *E. pulchra ;* it reaches beyond the distal end of the 1st basal of the right leg. A small endopod is present. The first two segments of the left ramus are of unequal length, the proximal being 20 to the distal 27 ; the 3rd segment is inserted on the side of the 2nd, so as to form the usual claw. The structure of the two branches of the claw on the right leg differs in detail from that of *E. messinensis* : in the exopod the 1st segment bears at about the junction of the proximal and distal thirds a rounded projection, as in *E. messinensis*, but the 2nd, somewhat smaller projection, just distal to this in *messinensis*, is in this species practically absent. In the endopod there is a rounded prominence on the outer margin just distal to the 1st rounded process of the exopod. The 2nd segment of the endopod bears a large number of transverse lamellæ, about 50 in all, which is many more than are present in *E. messinensis*.

Distribution.—Up to the present time this species has only been recorded from the Indian Ocean ; it has been taken in the Bay of Bengal (Sewell), the Arabian Sea and the

Gulf of Aden (present records). Its depth range would appear to be from about 400 metres to below 850 metres.

Euchirella pulchra (Lubbock). (Text-fig. 16, A–E.)

Undina pulchra, Lubbock, 1856, p. 26, pl. iv, figs. 5–8, pl. vii, fig. 6.
Euchirella pulchra, Giesbrecht, 1892, p. 233, pl. xv, figs. 22, 23, pl. xxxvi, figs. 13, 27; Esterly, 1905, p. 153, fig. 20; Wilson, 1932, p. 58, fig. 37.
Euchirella orientalis, ♂, Sewell, 1929, p. 118, fig. 44, *d*, *e*.

OCCURRENCE:

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., vertical, 2 females.
Sta. 172, Central part of the Arabian Sea, 200–0 m., 3 males; 850–0 m., 4 males.
Sta. 186, Gulf of Aden, 575–0 m., 2 males; 600–0 m., 3 males.

DESCRIPTIVE NOTES.—♀. Total length, 3·367 mm.

The proportional lengths of the cephalothorax and abdomen are as 79 to 21. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
396	134	99	84	74	94	36	26	26	31 = 1000

The forehead is rounded and is entirely devoid of a crest; the rostrum is slightly depressed and is directed vertically downwards. The line of separation between the cephalon and the 1st thoracic segment is clearly marked round the whole of the body. The posterior thoracic margin is rounded. In the abdomen (Text-fig. 16, A) the genital segment presents a rounded swelling on the left side and a well-marked ventral protrusion; the posterior margins of the first two segments are fringed dorsally with a row of rather delicate spines.

The 1st antenna reaches back to the end of the thorax. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	60	49	23	22	24	23	23	40	29	30	27	47	49	64	61	66	59	63

20.	21.	22.	23.	24–25.
52	46	46	41	56 = 1000

Segments 8 and 9 and 24 and 25 respectively are fused.

In the 2nd antenna the endopod is very short, and reaches only to a little beyond the middle of the 1st segment of the exopod. The total lengths of the two rami are as 24 to 76, so that the exopod is thus three times the length of the endopod; in the accounts given by previous workers this ramus is stated to be two-and-a-half times the length of the endopod.

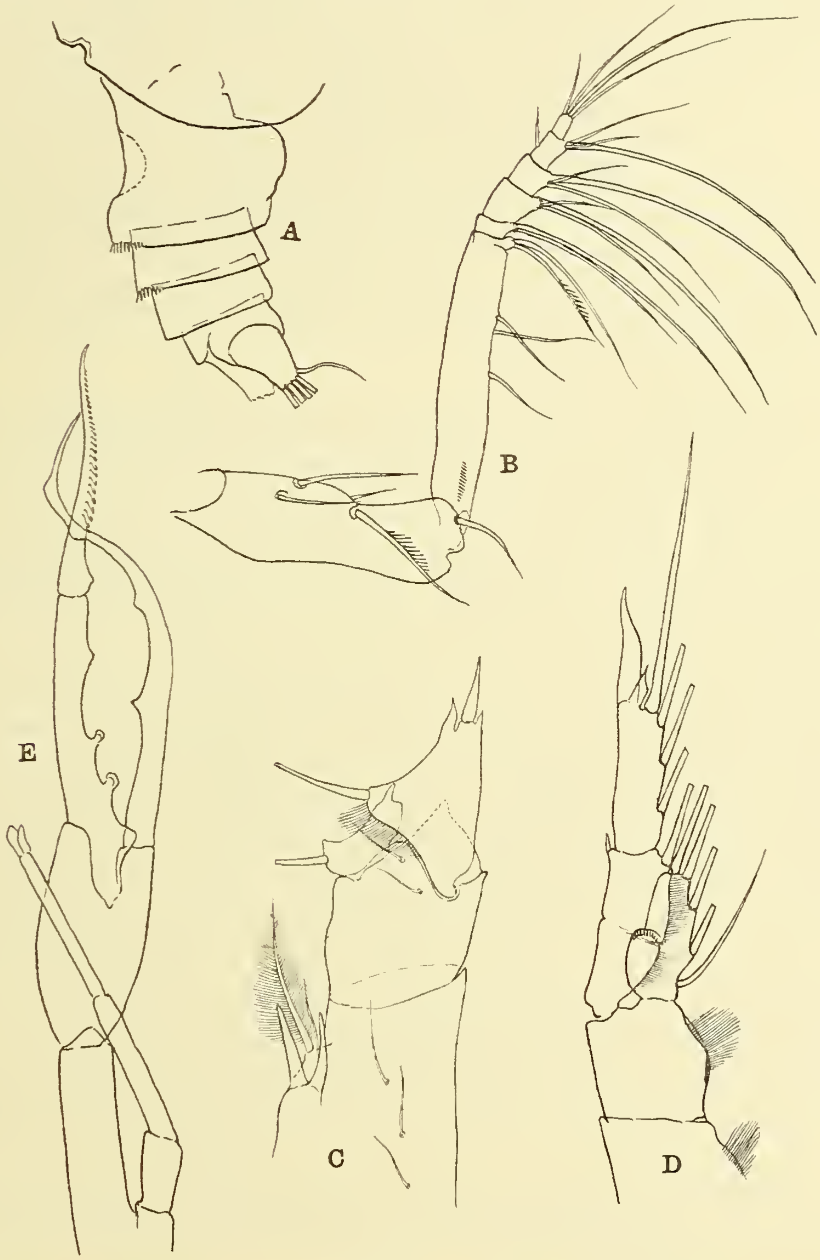
In the maxilla the 2nd inner lobe bears four stout setæ and the 3rd inner lobe two, the 2nd basal segment bears two setæ at its distal inner angle, the proximal of which is delicate, and the endopod bears 4 setæ; the exopod bears 11 setæ and the outer lobe 6.

In the maxilliped (Text-fig. 16, B) the proportional lengths of the two proximal segments are as 48 to 52. The posterior border of the 2nd segment is straight.

♂. Total length, 4·15 mm. This is somewhat larger than the specimen from the Bay of Bengal, described by me as the male of *E. orientalis*, which had a length of 3·7 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
476	79	79	95	79	60	52	44	8	28 = 1000



Text-fig. 16.—*Euchirella pulchra* (Lubbock). A, Abdomen, lateral view, ♀. B, Maxilliped, ♀. C, 4th leg, ♀. D, 1st leg, ♂. E, 5th pair of legs, ♂.

The forehead is rounded and there is a very low crest ; in my original account I stated that there was no crest, this is incorrect. A very low crest is present, though in some examples it appears to be little more than a linear thickening of the chitin. The 4th and 5th thoracic segments appear to be fused. The anal segment of the abdomen bears a tuft of hairs, but the segment itself is almost completely telescoped into the 4th segment.

The 1st antenna reaches back to about the middle of the 2nd abdominal segment. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9–10.	11.	12–13.	14–15.	16.	17.	18.	19.
Right	65	51	20	22	23	26	28	66	32	72	108	60	68	60	62
Left	62	48	21	21	25	25	26	65	30	71	107	62	67	60	63

	20–21.		22.	23.	24–25.	
Right	91		50	42	54	= 1000
Left	56	43	48	45	55	= 1000

There is thus a close agreement in the lengths of the segments, except where fusion of two or more segments has occurred, with the lengths in the female. In both antennæ the 8th and 9th segments are fused, and to these is fused the 10th ; the 12th and 13th are fused, and so are the 14th and 15th, and the 24th and 25th ; in addition to these the 20th and 21st are fused in the right antennule.

In the 2nd antenna the endopod is well developed and the proportional lengths of the two rami are as 19 to 29. In the exopod the 1st and 2nd segments are separate. The terminal joint of the endopod bears on the inner lobe 6 well-developed setæ, and on the outer lobe 5 well-developed setæ and a sixth small and delicate one.

The 1st leg (Text-fig. 16, D) very closely resembles that of *E. venusta* and *E. orientalis*, but the proportional lengths of the segments and the end spine of the exopod are slightly different ; the proximal joint, consisting of segments 1 and 2, has a length of 42, the 2nd segment 36 and the end-spine 24.

The 5th pair of legs (Text-fig. 16, E) is characterized by the relatively great length of the two basal segments of the right leg, which are together longer than the endopod. In the left leg the 2nd basal segment is very short, and reaches only about half way towards the end of the 1st basal of the right leg. In the right leg the exopod is composed of two segments, the proximal of which is produced in a blunt process near the base, while from the inner margin of the proximal half of the segment arise two processes, lamellar in character with rounded ends, and in the distal half a low pointed process arises at about the junction of the 3rd and 4th quarter. The terminal segment bears a row of about 25 projections, which, as With (1911, p. 124, fig. 31, *c*) has pointed out in the case of *E. messinensis*, are in reality keels, that in optical section appear as teeth.

Distribution.—This species occurs in all three great Oceans. In the Pacific it has been taken off the west coast of South America (Giesbrecht), the San Diego region (Esterly), and in the Malay Archipelago (A. Scott). In the Indian Ocean it Occurs off the west coast of Australia (Giesbrecht), and in the Arabian Sea and Gulf of Aden (present records). In the South Atlantic (Wolfenden), the Gulf of Guinea (T. Scott), the North Atlantic (Lubbock, Brady, Thompson), near the Cape Verde and Azores Islands (Sars), in the Gulf of Maine and the Woods Hole region (Bigelow, Wilson).

Euchirella truncata Esterly. (Text-fig. 17, A–E.)

Euchirella truncata, Esterly, 1911 (February), p. 322, pl. xxvi, fig. 5, pl. xxviii, fig. 35, pl. xxix, fig. 63, pl. xxx, fig. 71, pl. xxxi, fig. 104.

Euchirella gracilis, Wolfenden, 1911 (April), p. 237, fig. 22, pl. xxvii, figs. 8–10.

Euchirella intermedia, With, 1915, p. 124, fig. 32, pl. iv, fig. 4, *a–c*, pl. viii, fig. 3 ; Sars, 1925, p. 68, pl. xx, figs. 1–4.

OCCURRENCE :

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female, adult, 1 female juv., ? 1 male juv. ; 1500–0 m., 1 female adult.

Sta. 172, Central part of Arabian Sea, 400–0 m., 2 females, adult.

DESCRIPTIVE NOTES.—♀. Total length, 5·231–5·50 mm. This is smaller than the specimens taken by Esterly, which measured 6·6 mm., by With, that were 5·66 mm., by Sars, that were 6·20 mm., and by Wolfenden, that were 5·6–6 mm. The proportional lengths of the cephalothorax and abdomen are as 4·5 to 1, which agrees closely with With's specimen, in which they were as 4·66 to 1 ; Esterly states that the abdomen is a little more than one-sixth the length of the anterior region. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
356	161	99	91	85	97	28	22	18	38 = 1000

The line of separation between the cephalon and the 1st thoracic segment is in one specimen quite clear both dorsally and laterally ; in other examples it is only clear in the lateral region, as stated by With. The posterior thoracic margin is rounded, when viewed from the side, but when seen from the dorsal aspect is truncated, as described by Esterly and as clearly figured by Wolfenden. The genital segment (Text-fig. 17, A) is as deep as long and very nearly as wide as long ; it bears a well-developed ridge across the ventral aspect near the anterior margin ; With states that this ridge was not seen by him, and this may perhaps be accounted for by the fact that it lies almost exactly level with the posterior border of the thorax, and thus may have been obscured in his specimen. The left side of the genital segment is more swollen than the right, and behind this swelling there is a depression that is bordered posteriorly by a lamellar ridge ; in two specimens examined by me the head of attachment of a spermatophore was lodged in this depression. The anal segment bears a tuft of hairs ventrally. The furcal rami are as broad as long and are divergent ; they bear at the distal outer angle a short, delicate seta, and distally four plumose setæ of equal length.

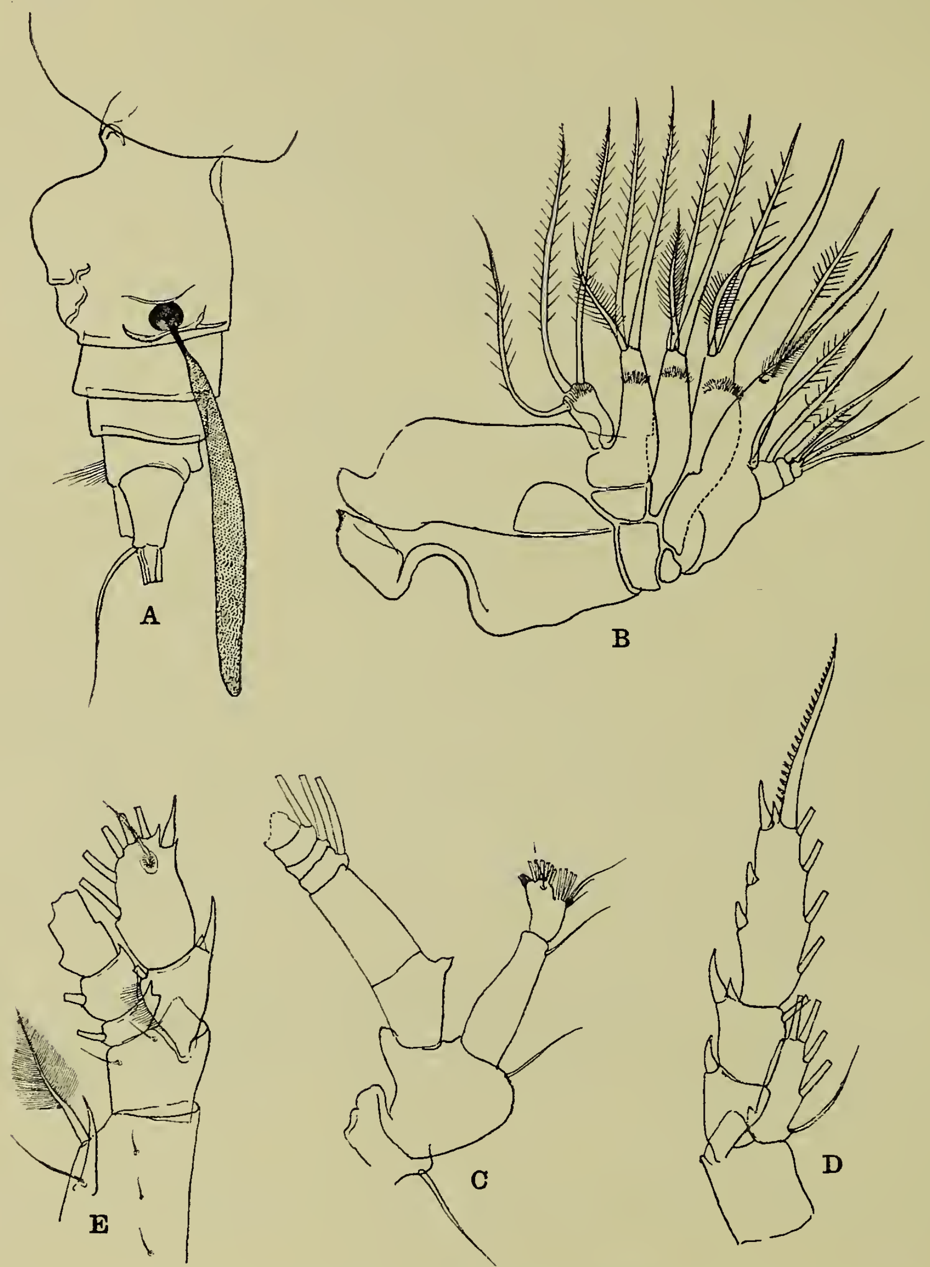
The 1st antenna reaches back to about the posterior end of the furcal rami ; there is a slight degree of variation in the different specimens, for in one it only reached to the posterior margin of the 2nd free abdominal segment, whereas in others it seemed slightly to exceed the length of the animal, as stated by Esterly. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	60	44	24	22	24	24	24	42	27	30	27	47	49	63	63	67	59	64

20.	21.	22.	23.	24–25.
60	48	49	38	45 = 1000

In the 2nd antenna (Text-fig. 17, C) the endopod is considerably better developed than in *pulchra*, *venusta*, *bella* or *orientalis*, and reaches nearly to the distal end of the 2nd segment of the exopod. The two proximal segments of the exopod are only partly fused, a faint line of division between them being visible posteriorly. From the anterior margin at about the junction of the proximal and middle thirds of the combined 1st and 2nd segments

arises a conical papilla ; Wolfenden states that there is a " lappet " on the 2nd segment, but he figures it as present at the distal end of the 1st. With (1915, p. 125) states that there are 9 setæ on each of the lobes of the last segment of the endopod ; I have been able to detect only 7 on each.



Text-fig. 17.—*Euchirella truncata* Esterly, ♀. a, Abdomen, lateral view. b, 2nd maxilla. c, 2nd antenna. d, 2nd leg, e. 4th leg, abnormal.

In the 1st maxilla the 2nd inner lobe bears 4 setæ and the 3rd lobe 2, of which one is quite small ; the 2nd basal segment bears 2 small and 1 well developed setæ ; the endopod bears 5 setæ, of which the inner is very small ; the exopod carries 11 setæ and the outer lobe 8, the posterior two being smaller than the others.

In the maxilliped the proportional lengths of the 1st and 2nd basal segments are as 41 to 51, and the posterior margin of the 2nd segment is straight.

The 1st leg has the usual structure. Segments 1 and 2 of the exopod are fused, and this combined joint bears two marginal spines. The proportional lengths of the two segments and the end-spine are as 15, 10 and 10.

In the 2nd leg (Text-fig. 17, D) the external marginal spine of the 2nd segment of the exopod is well developed and is considerably greater than the 1st and 2nd marginal spines of the 3rd segment; it does not, however, as is stated by Wolfenden, reach as far as the base of the 3rd spine of the 1st segment: Wolfenden's illustration of this leg shows that this spine is not quite so long.

The 4th leg bears on its 1st basal segment a single long and moderately stout spine, that reaches to, or nearly to, the end of the segment; immediately distal to the origin of this spine is a delicate seta. A stout plumose seta arises from the distal inner angle. In one specimen (Text-fig. 17, E) the exopod of the 4th leg on one side was represented by a two-jointed short ramus, the length of which was only equal to that of the endopod. The terminal segment carried 5 marginal setæ and a single marginal spine. Probably this abnormality was the result of injury.

Distribution.—This species has been recorded from various localities under different names. It has been recorded as *E. truncata* from the San Diego region of the eastern Pacific (Esterly); from the Arabian Sea (present records); from the South Atlantic as *E. gracilis* (Wolfenden); from the North Atlantic by Sars, and from the Atlantic in 51° N. as *E. intermedia* (With).

Euchirella venusta Giesbrecht. (Text-fig. 18, A–G.)

Euchirella venusta, Giesbrecht, 1892, p. 233, pl. xv, fig. 19, pl. xxxvi, fig. 21.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m. vertical, 1 male; 1500–0 m. vertical, 2 females.

Descriptive Notes.—♀. Total length, 4·383 mm.

The proportional lengths of the cephalothorax and abdomen are as 80 to 20. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
386	141	91	84	81	91	34	34	24	34 = 1000

The forehead is rounded and is entirely devoid of a crest. The rostrum is depressed and is directed vertically downwards. The line of separation of the cephalon and the 1st thoracic segment is clearly marked round the whole of the body. The posterior thoracic margin is rounded. In the abdomen (Text-fig. 18, A) there is a rounded prominence on the left side of the genital segment, and a high ridge runs across the ventral part of this segment in front of the genital aperture; the present specimens agree closely with the figure given by Giesbrecht (1892, pl. xxxvi, fig. 21). The posterior margins of the genital and the next following segments are fringed dorsally with a row of spinules. The anal segment bears a tuft of hairs on the ventral aspect.

The 1st antenna reaches back to about the middle of the abdomen. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	58	39	19	20	21	21	21	37	25	29	29	46	51	69	69	74	65	70

20.	21.	22.	23.	24–25.	
58	48	45	37	49	= 1000

In the 2nd antenna the endopod is exactly one-quarter the length of the exopod.

In the 1st maxilla the number of setæ on the various lobes appears to be exactly the same as in *E. pulchra* (Lubbock).

In the maxilliped (Text-fig. 18, B) the proportional lengths of the two basal segments are as 42 to 58; the 2nd segment is thus considerably longer in proportion to the 1st segment than in *E. pulchra* (Lubbock). The posterior margin of the 2nd basal segment exhibits a pair of rounded prominences in the distal half of its length.

In the 4th leg (Text-fig. 18, D) the ridge bearing the spines on the postero-inner border is much nearer the distal end of the segment than in *E. pulchra* (Lubbock), so that the tips of the spines are on a level with the distal end of the segment. In most cases there is a pair of spines present, but in one example there were three spines on one side and two on the other.

At the same station, at which the females were obtained, but at a higher level (500–0 metres) a single male was taken that I believe to belong to the same species.

♂. Total length, 3·80 mm.

The proportional lengths of the cephalothorax and abdomen are as 79 to 21. The proportional lengths of the various segments of the body are as follows:

Cephalon & Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
484	84	80	96	68	56	48	40	12	32 = 1000

The forehead is rounded and is entirely devoid of any crest. The rostrum is depressed and is directed vertically downwards. There is no trace of any line of separation between the cephalon and the 1st thoracic segment, and segments 4 and 5 also appear to be fused, the 5th segment merely forming a low crest along the lateral part of the region. The 2nd and 3rd segments of the abdomen are armed in the dorsal region with a row of strong triangular spinules. The anal segment bears a tuft of hairs on its ventral aspect; this segment is entirely telescoped into the preceding one.

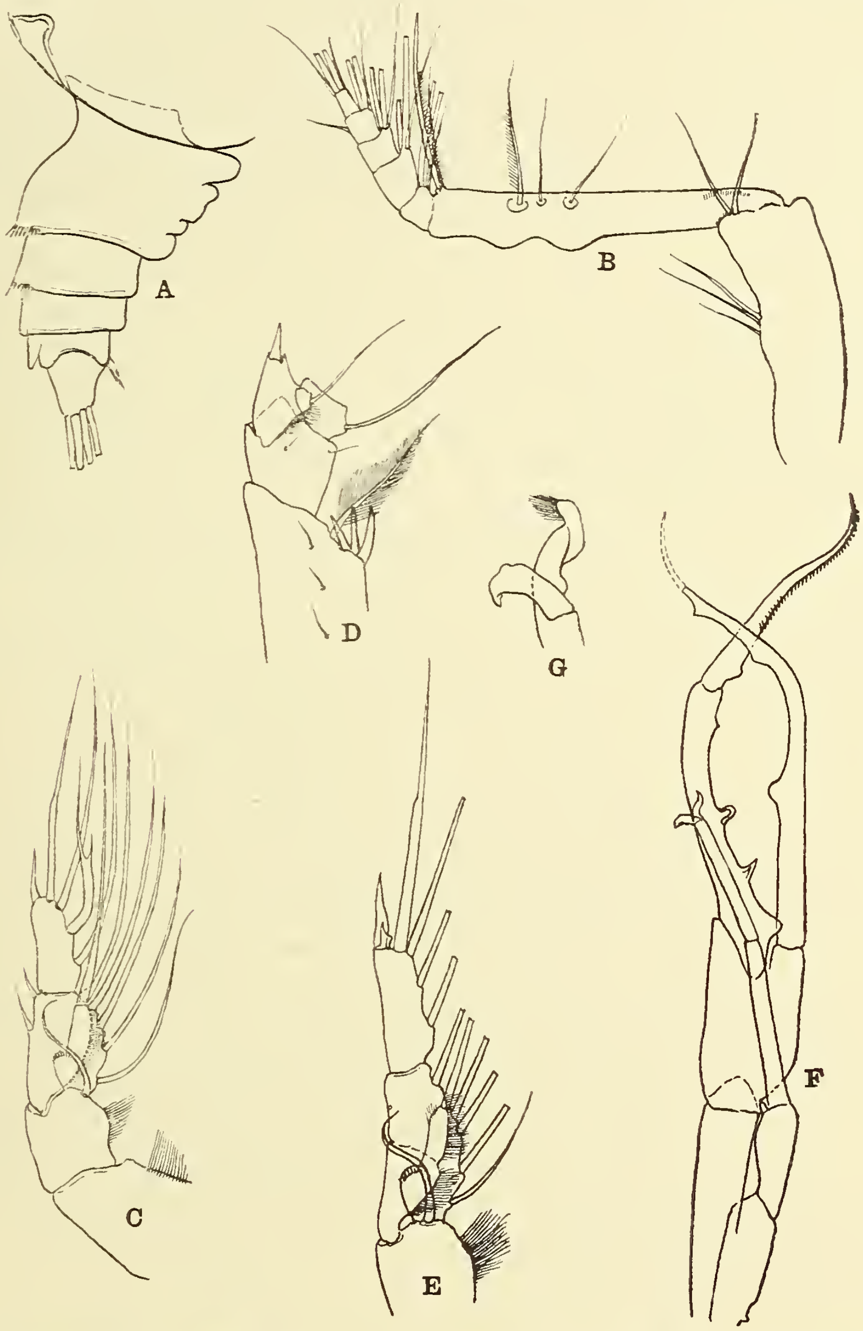
In the 1st antenna on both sides the 8th and 9th segments are completely fused and the 10th is fused to the 9th, though traces of the line of fusion can be detected; the 12th and 13th, and the 14th and 15th segments, respectively, are fused, though traces of the fusion are visible; segments 24 and 25 are fused. In the right antenna segments 20 and 21 are also fused completely.

The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12–13.	14.	15.	16.	17.	18.	19.
Left	68	43	19	17	21	22	23	35	24	25	70	50	62	64	70	64	64
Right	66	46	19	17	21	23	23	37	22	27	69	49	63	63	71	62	66

20.	21.	22.	23.	24–25.	
59	49	52	49	50	= 1000
105		53	48	50	= 1000

In the 2nd antenna the endopod is much better developed than in the female, and the proportional lengths of the two rami are 39 to 61. The exopod in this sex is composed of seven segments, the 1st and 2nd being separate instead of fused. The endopod bears



TEXT-FIG. 18.—*Euchirella venusta* Giesbrecht. A, Abdomen, lateral view, ♀. B, Maxillipied ♀. C, 1st leg, ♀. D, 4th leg, ♀. E, 1st leg, ♂. F, 5th pair of legs, ♂. G, Terminal claw of left 5th leg, ♂.

on its two lobes 6 setæ, all well developed, on the inner, and 5 well developed and 1 small and delicate on the outer.

The mandible is devoid of any biting ramus.

The 1st maxilla is also reduced. The 1st inner lobe is reduced to a rounded process without any setæ or spines ; the 2nd and 3rd inner lobes are absent ; the basal segment bears at its distal end 2 delicate inner setæ and 3 stout outer setæ, these latter apparently corresponding to the setæ that arise from the endopod in the female ; the exopod bears 10 stout setæ and the outer lobe has 5 delicate setæ.

The 2nd maxilla is reduced to a fleshy lobe that bears at its extremity a single segment, carrying 5 delicate setæ.

The maxilliped is also somewhat reduced, though all its parts are present. The proportional lengths of the two basal segments are as 36 to 64. The rounded prominence at the distal end of the anterior border of the 1st basal segment is fringed with small spinules.

In the 1st leg (Text-fig. 18, E) the exopod consists of only two segments, segments 1 and 2 being fused, though there is a very small notch in the outer margin and another in the inner border that denote the line of fusion. I was unable to detect any marginal spines on the proximal segment of the exopod. The distal segment is about three-fourths the length of the proximal, and the distal spine is strong and about four-sevenths the length of the segment, the actual proportions being 47, 35 and 20.

The 5th pair of legs (Text-fig. 18, F, G) very closely resemble those of *Euchirella messinensis*. In the left leg the 2nd basal segment does not reach as far as the distal end of the 1st basal segment of the right leg, but is much longer than in *E. pulchra* (Lubbock). There is a very small endopod present. In the exopod the 1st and 2nd two segments are of equal length ; the small 3rd segment is inserted a short distance before the end of the 2nd segment, so as to form a minute claw. In the right leg the proportional lengths of the two basal segments are as 34 to 27. The exopod is composed of two segments and the endopod of one. The proximal segment of the exopod is produced in a rounded prominence on its inner side near the base, and on the inner margin are three prominences ; the first of these, situated at about one-fourth the length of the segment, is sharply pointed, the second, about half-way along its length, is bluntly rounded, and the third is quite small and is situated near the distal end. The distal segment bears on its inner border a row of about 35 ridges. The inner ramus is S-shaped ; it bears on its outer margin, just distal to the 2nd prominence on the exopod, a rounded projection, and at about the junction of the middle and distal thirds a low triangular projection ; a still smaller angular projection is present about half-way along the distal third of its length. The total length of the exopod, compared with the total length of the two basal joints, is as 71 to 66.

Distribution.—This species would appear to be confined to the Indo-Pacific region. It has been recorded from the west coast of South America (Giesbrecht, Dana), off New Zealand (Farran), in the southern area of the Arabian Sea (present record), and off Cape Colony in the Agulhas Current (Cleve).

" Curticauda " Group.

Euchirella maxima Wolfenden. (Text-fig. 19, A–G.)

Euchirella maxima, Wolfenden, 1905, p. 18, pl. vi, figs. 9–11 ; A. Scott, 1909, p. 57, pl. xii, figs. 12–20 ; Wolfenden, 1911, p. 238, text-fig. 24, *a*, *b*, pl. xxviii, figs. 3–5 ; With, 1915, p. 127, text-fig. 33, *a–i*, pl. iv, fig. 5, *a–h* ; Sars, 1926, p. 75, pl. xxii, figs. 1–7 ; Sewell, 1929, p. 112, text-figs. 42 and 43.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female, 1 male juv.

Sta. 76. Gulf of Oman, 600–0 m., 1 female, 1 male adult, 1 male juv.

Sta. 131 D. Southern area of Arabian Sea. 1500–0 m., 1 female adult, 1 female juv., 1 male adult, 1 male juv.

Sta. 186, Gulf of Aden, 575–0 m., 3 females adult.

Descriptive Notes.—♀. Total length, 7·25 mm.

The proportional lengths of the cephalothorax and abdomen are as 4·8 to 1. The proportional lengths of the various segments are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.-2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
411	137	88	87	83	13	68	32	28	20	33 = 1000

The forehead is crowned by a high crest and the rostrum is small and stout. The cephalon and 1st thoracic segment are fused. but in a stained specimen the line of fusion can still be seen, especially in the lateral region. The 4th and 5th thoracic segments are fused, but the 5th segment forms a rounded lappet on the posterior thoracic margin.

The 1st antenna reaches back to the posterior margin of the genital segment. The proportional lengths of the various segments are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
63	69	27	26	26	25	25	44	29	29	31	43	47	67	64	67	59	54

20.	21.	22.	23.	24–25.	
52	42	40	33	40	= 1000

Segments 3, 7, 9, 14, 18, 21, 23, 24 and 25 each bear a long seta.

In the 2nd antenna the 1st basal segment bears a row of long hairs on its inner aspect. The endopod is much reduced and the proportional lengths of the two rami are as 27 to 75. In the endopod the outer lobe of the terminal segment bears 5 setæ that decrease in size outwards, and the inner lobe bears 3 large and 2 small setæ ; this agrees with the accounts given by Wolfenden and A. Scott, but differs from that of With ; this last author seems to have failed to see the two small setæ on the outer lobe. With (*loc. cit.*, p. 127) states that the proximal two segments of the exopod are " well separated " ; in the present specimen they are fused, but the line of fusion is clearly visible. Segment 1 bears, as With has pointed out, a conical process without a seta.

The mandible is furnished with a powerful biting ramus.

In the 1st maxilla the 2nd inner lobe bears four stout setæ, and the 3rd has two small setæ and between them a single large one. The 2nd basal segment bears 2 small and 1 large seta : the endopod carries 3 large setæ, and the exopod has 11. The outer lobe bears 8 setæ, of which the proximal three and the 5th are smaller than the others.

In the maxilliped the proportional lengths of the two basal segments and the endopod are as 56, 68 and 31. The 2nd basal segment bears, near the proximal end, a band of fine spines, instead of a single row such as is present in *E. bella*, *pulchra*, *truncata*, *venusta*, *orientalis* and *galeata*. In the endopod the 2nd segment bears 4 setæ instead of only 3.

In the 1st leg the fusion of the first two segments of the exopod is complete ; the

segment bears two moderately stout marginal spines. The proportional lengths of the two segments and the end spine are as 90, 73 and 43.

♂. Total length, 7·02 mm.

Text-fig. 19.—*Euchirella maxima* Wolfenden. A, 1st maxilla, ♂. B, 2nd maxilla, ♂. C, 2nd maxilla, ♀. D, 1st leg, ♂. E, 2nd leg, ♂. F, 2nd leg, ♀. G, 5th pair of legs, ♂.

The proportional lengths of the cephalothorax and abdomen are as 79 to 21. The proportional lengths of the various segments of the body are as follows :

Cephalon & Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
528	77	65	94	50	52	48	37	11	35 = 1000

The cephalon and 1st thoracic segment are fused, and so are the 4th and 5th thoracic segments. The posterior thoracic margin is rounded. Segments 2, 3 and 4 of the abdomen are fringed posteriorly with a palisade of delicate spines. The anal segment is almost completely telescoped into the 4th, and bears a tuft of hairs ventrally.

The 1st antenna reaches back to the posterior margin of the 2nd abdominal segment. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9–10.	11.	12–13.	14–15.	16.	17.	18.	19.	20.
	74	40	25	24	25	26	27	74	25	60	79	48	52	53	66	61

21.	22.	23.	24–25.	
51	74	61	55	= 1000

In the left antenna segments 8, 9 and 10 are fused, and so are segments 12 and 13, 14 and 15, and 24 and 25 respectively ; in the right antenna segments 20 and 21 are also fused. Segment 3 bears a long seta, but in the more distal segment these are much less well developed than in the female.

In the 2nd antenna the two rami are of approximately equal length. The 1st basal segment bears a row of hairs. The 1st and 2nd segments of the exopod are separate, and the distal segment of the endopod bears 8 and 7 setæ respectively on the two lobes.

The mandible is reduced and the biting ramus is absent.

In the 1st maxilla (Text-fig. 19, A) the three inner lobes are greatly reduced in size and are devoid of any spines or setæ ; the 2nd basal segment bears on its inner margin two very unequal setæ, and beyond this are two distinct segments, of which the first bears on its inner margin two lobes each bearing a proximal small and a distal long seta ; the distal segment is small and bears four setæ. The exopod is well developed and carries 11 setæ, and the outer lobe is also well developed and bears 5 large and 1 small setæ.

The 2nd maxilla (Text-fig. 19, B) is similar to that of *E. curticauda*, as figured by With (1915, pl. iv, fig. 3 *h*).

The maxilliped is comparatively well-developed.

In the 1st leg (Text-fig. 19, D) the exopod is composed of three separate segments each bearing a single marginal spine.

In the 2nd leg (Text-fig. 19, E) the marginal spine of the 2nd segment of the exopod is of remarkable length, and reaches nearly to the distal end of the 2nd spine of the 3rd segment : in this respect this specimen appears to differ radically from the one examined by With, for he remarks (1915, p. 129) on the "comparatively short Se Re II." In this sex the endopod is composed of two segments, segment 1 being clearly separated off.

The 5th pair of legs (Text-fig. 19, G) resembles in its general form the corresponding appendage of *E. curticauda*, *E. rostrata* and *E. rostromagna*. With (1915, p. 120) states that the 5th leg of *E. curticauda* "shows similarity not only to that of *E. messinensis* but also to that of *E. rostrata*," but he seems to have overlooked certain essential differences

in the two types of limb, and the 5th leg of *E. maxima* agrees well with the type found in the three above-mentioned species, and differs essentially from the type present in *E. messinensis*, *bella*, *orientalis* and *pulchra*. There appear to be certain minor differences in the legs of the present form and that of the examples described by With and Sars.

Distribution.—This species has now been taken in the Malay Archipelago (A. Scott), the Bay of Bengal and the Laccadive Sea (Sewell), the Arabian Sea and the Gulf of Aden (present records), the South Atlantic as far as 36° S. (Wolfenden), the North Atlantic (Sars), the west coast of Ireland (Farran), and the North Atlantic as far north as 61° N. (With).

Genus *Chirundina* Giesbrecht.

Chirundina, Giesbrecht, 1895, p. 249.

Chirundina indica Sewell. (Text-fig. 20, a–e.)

Chirundina indica, Sewell, 1929, p. 119, text-figs. 45, *a*, *b*, and 46, *a–j*.

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 12 females, adult, 2 juv.; 1 male, juv.

Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., 2 females, adult; 1 male, adult.

Sta. 145 C, Maldive area, 500–0 m., 3 females, adult.

Sta. 145 D, Maldive area, 300–0 m., 3 females, adult; 1 male, juv.; 500–0 m., 2 females, adult.

Sta. 172, Central part of Arabian Sea, 400–0 m., 23 females, adult; 850–0 m., 63 females, adult.

Sta. 186, Gulf of Aden, 575–0 m., 6 females, adult; 950–0 m., 44 females, adult.

Descriptive Notes.—♀. Total length ranging from 4·05 to 5·00 mm., the average being 4·60 mm. This species is thus slightly smaller than *Chirundina streetsi*, which ranges from 4·8 to 5·3 mm.

The proportional lengths of the cephalothorax and abdomen are as 79 to 21, or 3·8 to 1. In my earlier account of this species I gave the proportional lengths as 4·7 to 1.

The fusion of the cephalon and 1st thoracic segment is not quite complete, the line of fusion being visible in the mid-dorsal line, as in *C. streetsi*, but slightly more extensively.

The proportional lengths of the various segments of the body are as follows :

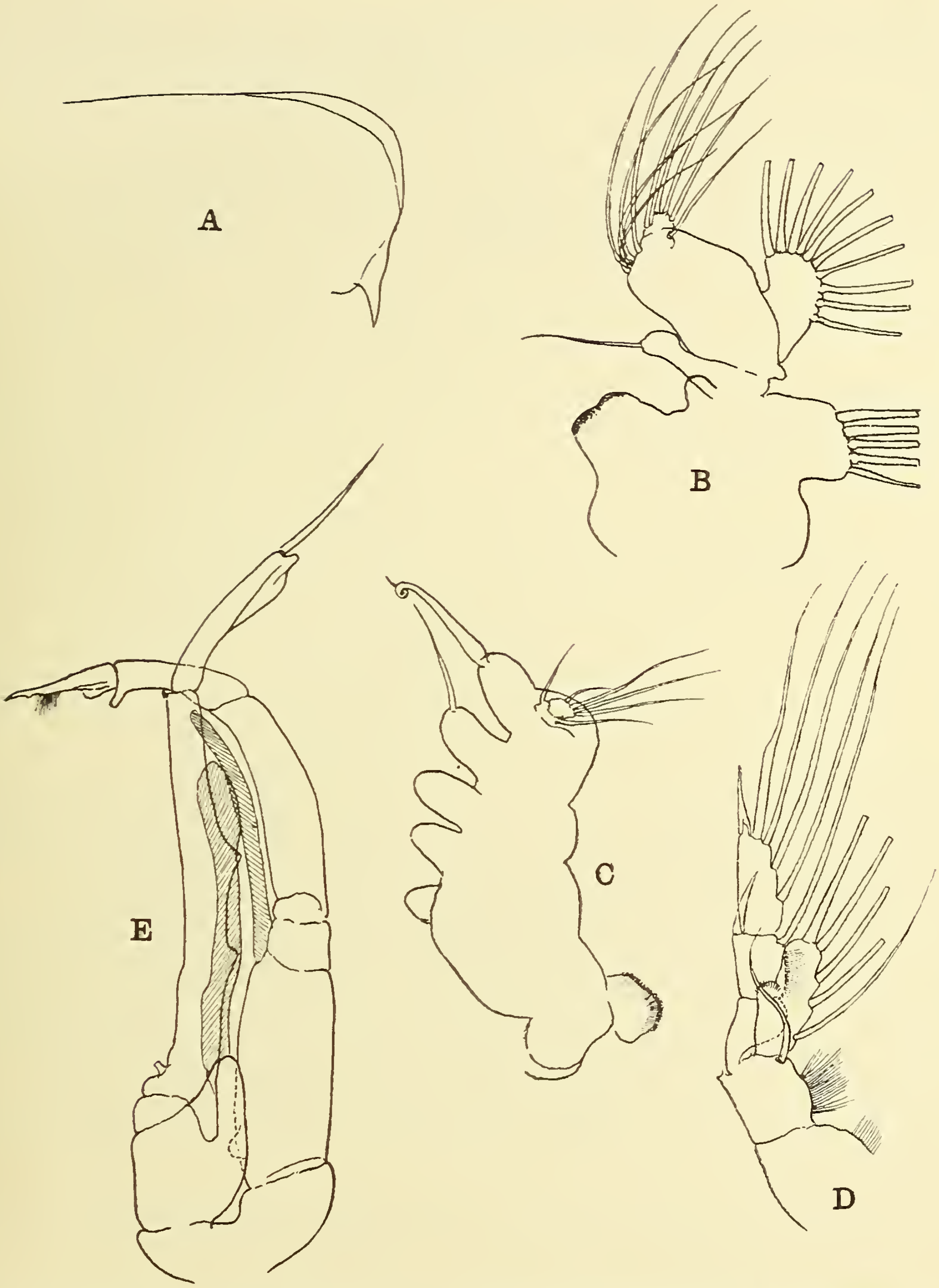
Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
519 (374, 145)	94	81	67	101	47	34	20	37 = 1000

The proportional lengths of the various segments of the 1st antenna are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
64	47	27	26	30	30	32	48	29	31	26	45	44	51	51	54	49	68

20.	21.	22.	23.	24–25.
58	41	47	51	51 = 1000

There is thus little or no difference between this and the preceding species.



TEXT-FIG. 20.—*Chirundina indica* Sewell, ♂. A, Frontal region, lateral view. B, 1st maxilla. C, 2nd maxilla. D, 1st leg. E, 5th pair of legs.

The mouth parts appear to be identical with those of *C. streetsi*.

As I have previously pointed out, the 1st leg differs from that of *C. streetsi* in that the proximal segment of the exopod, which is partly fused with the 2nd segment, is devoid of any marginal spine.

Associated with the two females of this species and one of *C. streetsi* at Sta. 131 D, 1500–0 m., was a single adult male, which I believe to be the hitherto unknown male of this species.

♂. Total length, 3·967 mm.

With gives the total length of the male of *C. streetsi* as 3·80 mm., and A. Scott's specimen from the Malay Archipelago measured 4·1 mm. The proportional lengths of the various segments of the body are as follows :

Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.	
494	91	77	73	57	69	57	45	8	29	= 1000

The forehead (Text-fig. 20, A) is crowned by a small, and somewhat inconspicuous crest, considerably smaller than in *C. streetsi*.

In the 1st antenna the proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9–10.	11.	12–13.	14.	15.	16.	17.	18.	19.
Right	72	46	23	22	26	26	28	70	31	69	43	51	54	57	50	67
Left	71	46	22	21	26	26	30	71	30	71	43	51	54	56	51	67

	20.	21.	22.	23.	24–25.	
Right	100		55	57	53	= 1000
Left	61	42	54	56	51	= 1000

Segments 8 and 9 are completely fused and 9 is almost completely fused with 10, only a trace of the line of fusion being visible ; segments 12 and 13 are also fused ; in addition to these, in the right antenna segments 20 and 21 are fused. According to With (1915, p. 143) in *Chirundina streetsi* segments 20 and 21 are separate in both antennæ.

In the 2nd antenna the 1st basal segment bears a row of hairs. The proportional lengths of the endopod and exopod are as 3 to 4. The distal segment of the endopod carries on the outer lobe 8 well-developed setæ, and on the inner 5 well-developed setæ and 3 much smaller ones, the innermost being minute. In the exopod the two proximal segments are separate, and the 1st bears a prominence that is devoid of any seta ; With (1915, p. 143) states that in *C. streetsi* the 2nd segment bears " 2 basal processes and a single terminal one," but I could only detect a single process close to the proximal border in the present specimen.

The mandible is devoid of a biting ramus, but the palp is well developed.

In the 1st maxilla (Text-fig. 20, B) the 1st inner lobe is represented by a rounded process. The 2nd inner lobe is very small and is devoid of any setæ. The 3rd inner lobe is moderately well formed and bears a single seta. The 2nd basal segment and the endopod together bear 10 or 11 small setæ. The exopod carries 10 well-formed, long flexible setæ, and the outer lobe bears 5 long setæ.

The 2nd maxilla (Text-fig. 20, C) is much reduced. It bears 5 lobes, of which the proximal three are devoid of any setæ and the 4th and 5th bear one each. The terminal portion bears 6 very small setæ.

The maxilliped is moderately well developed.

In the 1st leg (Text-fig. 20, D) the exopod is composed of three segments, segments 1

and 2 being separate: the proximal segment is, however, entirely devoid of a marginal spine or seta, thus resembling the female and differing from the male of *C. streetsi*, which possesses a short marginal spine on this segment.

The 2nd–4th legs resemble those of the female.

The 5th pair of legs (Text-fig. 20, E) appears to be almost identical with those of *C. streetsi*.

DISTRIBUTION.—Up to the present time this species has only been recorded from the Laccadive Sea (Sewell), the Arabian Sea and the Gulf of Aden (present records).

Chirundina streetsi Giesbrecht.

Chirundina streetsi, Giesbrecht, 1895, p. 250, pl. i, figs. 5–10; Esterly, 1906, p. 59, pl. ix, fig. 2, pl. x, fig. 28, pl. xii, fig. 58, pl. xiv, figs. 86, 87; A. Scott, 1909, p. 43, pl. xii, figs. 1–11; Sars, 1925, p. 77, pl. xxii, figs. 8–13.

OCCURRENCE:

Sta. 96, Central part of Arabian Sea, 645–400 m., 4 juv.

Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., 1 female, adult.

Sta. 145 D, Maldive area, 300–0 m. vertical, 1 juv.; 500–0 m. vertical, 1 juv.

Sta. 172, Central part of Arabian Sea, 850–0 m., 9 juv.

DESCRIPTIVE NOTES.—♀. Total length, 5·35 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 to 24. The proportional lengths of the various segments of the body are as folllows:

Cephalon & Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
526	108	87	57	90	46	34	18	34 = 1000

The cephalon and 1st thoracic segment are fused but, as pointed out by With (1915, p. 141), a trace of segmentation can be seen in the mid-dorsal line. The 4th and 5th thoracic segments are fused, and in the present specimen the posterior margin presented the form shown by Giesbrecht (1895, pl. i, fig. 10), and With (1915, fig. 38, *d*), being produced backwards in a wing-like, rounded prominence crowned by a small papilla. The genital segment is produced in a prominence ventrally with a well-marked ridge anterior to the genital aperture, from which the profile slopes gradually downwards to the posterior margin. The 3rd free (4th) segment is fringed along the posterior margin dorsally with a double row of needle-like spinules. The anal segment bears a tuft of hairs on its ventral aspect.

The 1st antenna extends backwards as far as the furcal rami. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	68	46	27	27	30	32	31	47	29	30	26	44	43	51	52	57	49	68

20.	21.	22.	23.	24—25.	
61	40	44	50	48	= 1000
				39 9	

The 8th and 9th segments are fused and so are the 24th and 25th, though in the present specimen the fusion appears to be incomplete.

In the 2nd antenna the proportional lengths of the exopod and endopod are as 42 to 23. The proximal two segments of the exopod bear, as pointed out by With, setæ that arise from papillæ, one on the proximal segment and three on the 2nd segment.

The 1st maxilla agrees with the description given by Giesbrecht.

In the maxilliped the proportional lengths of the two basal segments and the endopod are as 40, 63 and 17. The elongate 2nd basal segment bears a long linear lamella on its posterior border, the central portion being somewhat emarginate.

The 1st leg, as pointed out by Giesbrecht, has a two-jointed exopod, the segmentation between the 1st and 2nd segments being incomplete ; the 1st segment bears a slender, seta-like marginal spine.

Distribution.—In the Pacific Ocean off the coast of California in the San Diego region (Esterly), in lat. 35° N., long. 125° W. (Giesbrecht), off New Zealand (Farran) and in the Malay Archipelago (A. Scott). In the Indian Ocean from the Maldive area, the central and southern areas of the Arabian Sea (present records), and from the Agulhas current off Cape Colony (Cleve). In the Atlantic Ocean from the southern region (Wolfenden), in the North Atlantic (Wolfenden, Sars, van Breemen, Lysholm and Nordgaard, Rose), the Bay of Biscay and the west coast of Ireland (Farran), off the east coast of North America in the Gulf of Maine (Bigelow) and the Woods Hole Region (Wilson), and South of Iceland, as far north as lat. 63° 30· N′ (With).

Genus *Pseudochirella* Sars.

Pseudochirella, Sars, 1920, p. 5 ; *id.*, 1925, p. 83 ; Sewell, 1929, p. 127.

A number of species that had previously been referred to other genera have been transferred by Sars to this genus, and several other species described by other authors should, in my opinion, be included here. I give below a list of the species that I believe should be ascribed to this genus.

Pseudochirella calcarata Sars.
P. cryptospina Sars (= *Gaidius parvispina* Farran).
P. dentata A. Scott.
P. divaricata Sars.
P. dubia Sars.
P. elongata (Wolfenden), from *Euchirella.*
P. fallax Sars.
P. granulata (A. Scott), from *Euchirella.*
P. hirsuta (Wolfenden), from *Euchirella.*
P. lobata Sars.
P. magna (Wolfenden), from *Chirundina.*
P. notacantha Sars.
P. obesa Sars.
P. obtusa Sars (= *Chirundina abyssalis* With, *Euchirella dubia* A. Scott).
P. palliata Sars.
P. pustulifera Sars (= *Euchirella wolfendeni* Farran).
P. scopularis Sars.
P. spinosa (Wolfenden), from *Euchirella.*
P. superba (With), from *Undeuchæta.*

Pseudochirella magna (Wolfenden). (Text-fig. 21, A–C.)

Chirundina magna, Wolfenden, 1911, p. 241, text-fig. 27, pl. xxviii, figs. 10–13.
Pseudochirella magna, Sewell, 1929, p. 129, fig. 49, *a*, *b*.

OCCURRENCE:

Sta. 96. Central part of Arabian Sea, 645–400 m., 1 female.

Sta. 145 C, Maldive Area, 500–0 m. vertical, 1 juv.

Sta. 145 D, Maldive Area, 300–0 m. vertical, 1 juv.

DESCRIPTIVE NOTES.—♀. Total length, 8·0 mm.

This is considerably larger than the specimens originally taken by Wolfenden in the central and southern part of the Atlantic, which measured 6·0–6·6 mm. in length, or those taken by the "Investigator" in the Laccadive Sea, which were 6·2 mm. in length. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
386	171	89	83	73	83	30	29	14	41 = 1000

The forehead (Text-fig. 21, A) bears a short median crest. The cephalon and 1st thoracic segments are fused, but the line of fusion can be clearly seen in the stained specimen. The 4th and 5th thoracic segments are fused, and the posterior thoracic margin is emarginate in the dorso-lateral region and rounded posteriorly.

The genital (Text-fig. 21, B) segment is produced ventrally in a rounded swelling. The anal segment bears a tuft of hairs on the ventral aspect.

The 1st antenna over-reaches the furcal rami by about the last three segments. Wolfenden, in his original account of this species, states that this appendage over-reaches the furca by the last 4 or 5 segments. The proportional lengths of the various segments are as follows:

Segment.	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	61	37	19	19	23	24	24	44	23	24	24	37	39	48	49	56	56	73

20.	21.	22.	23.	24.	25.
69	56	77	61	38	19 = 1000

The line of separation between the 12th and 13th segments appears to be less complete than the others; segments 24 and 25 are separate.

In the 2nd antenna the 1st basal segment bears a row of hairs. The proportional lengths of the endopod and exopod are as 32 to 52. The endopod bears 6 setæ on each of the two lobes of the terminal segment, and these setæ are comparatively small and delicate. The setæ arising from the exopod are very long and plumose.

The biting ramus of the mandible is powerful, and the setæ of the palp are long and plumose.

In the 1st maxilla the setæ arising from the various lobes, etc., are as follows:

From Inner Lobe 1,	14 stout setæ.
,, ,, 2,	4 setæ.
,, ,, 3,	4 ,,
,, Basal 2,	3 ,,
,, the Endopod,	3, 3 and 5 setæ.
,, Exopod,	11 setæ.
,, Outer lobe,	9 ,,

In the 2nd maxilla the basal segment bears on its posterior margin a nipple-like prominence. The number of setæ arising from the various lobes are as follows :

From Lobe 1,	3 setæ.	
,, ,, 2,	3 ,,	
,, ,, 3,	3 ,,	
,, ,, 4,	3 ,,	
,, ,, 5,	3 ,,	
,, Endopod,	2, 1 and 3 setæ from the various segments.	

In the maxilliped (Text-fig. 21, c) the proportional lengths of the two basal segments are as 46 to 65.

The rounded prominence at the distal end of the 1st basal segment bears very fine spinules ; it is not smooth as I previously stated (1929, p. 130). From this lobe arise three setæ and a forwardly-directed nipple-like prominence, which bears a very small blunt process.

The 1st and 2nd swimming legs agree exactly with the descriptions given by Wolfenden (*loc. cit.*).

The 4th pair of legs bears, as I have previously noted, a row of 13 fine needle-like spines on the 1st basal segment.

DISTRIBUTION.—This species has now been recorded from the Laccadive Sea (Sewell), the Maldive Area and the central part of the Arabian Sea (present records), and from the equatorial and southern regions of the Atlantic Ocean.

? *Pseudochirella notacantha* Sars. (Text-fig. 21, D.)

Gaidius notacanthus, Sars, 1905, p. 5 ; Farran, 1908, p. 33, pl. iii, fig. 7.
Chirudina notacantha, With, 1915, p. 148, text-fig. 41 *a–k*, pl. v, figs. 7 *a*, *b*, pl. vi, figs. 1 *a*, *b*.
Pseudochirella notacantha, Sars, 1925, p. 86, pl. xxiv, figs. 7–12 ; Farran, 1929, p. 232 ; Jespersen, 1934, p. 66.

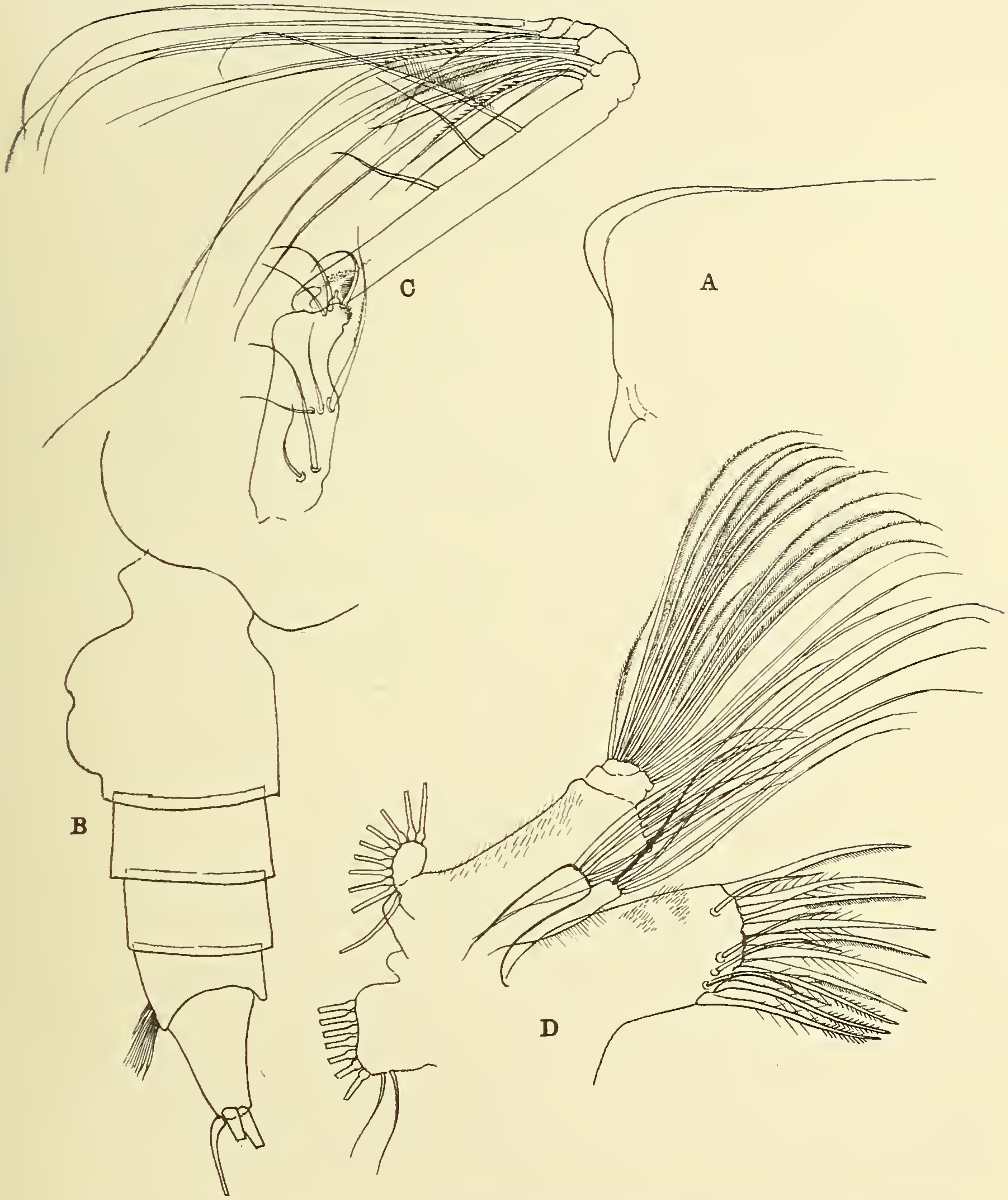
OCCURRENCE.—Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 female (immature).

DESCRIPTIVE NOTES.—Copepodid Stage V, ♀. Total length, 4·484 mm.

The proportional lengths of the cephalothorax and abdomen are as 79 to 21. The abdomen consists of only four segments, segments 4 and 5 still being fused. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
412	158	89	75	45	14	51	48	37	37	34 = 1000

The dorsal profile slopes gradually down to the extreme anterior end, and the rostrum is stout and is directed downwards and slightly backwards. The cephalon and 1st thoracic segments are still separate, though fusion appears to have begun ; during the process of dissecting the specimen the cuticle split across the body along the line of separation between the two regions. The posterior thoracic margin is produced backwards in a stout spine that reaches to about three-fourths of the 1st abdominal segment ; immediately below the spine the posterior margin forms a wing-like flap. The 2nd and 3rd abdominal



TEXT-FIG. 21.—*Pseudochirella magna* (Wolfenden), ♀. A, Frontal region, side view. B, Abdomen, lateral view. C, Maxilliped. *Pseudochirella notacantha* Sars, ♀. D, 1st maxilla.

segments are hairy on the dorsal surface. A tuft of hairs arises from the ventral aspect of the anal segment, and the dorsal aspect of the furcal rami bear some long hairs. The 1st antenna reaches back to the posterior margin of the 3rd abdominal segment. The proportional lengths of the various segments are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12–13.	14.	15.	16.	17.	18.	19.
75	47	27	26	29	29	29	46	28	29	71	39	48	49	53	44	67

20.	21.	22.	23.	24.	25.
63	43	50	54	42	12 = 1000

Segments 8 and 9 are completely fused, and 12 and 13, apparently, are partially so ; segments 24 and 25 also are partially fused.

In the 2nd antenna the proportional lengths of the endopod and exopod are as 25 to 42. Of the terminal lobes of the 2nd segment of the endopod, the inner bears 7 setæ and the outer 6. In the exopod the 1st and 2nd segments are separate, and I was able to detect the short process on segment 1, which With states is present. Segment 2 bears a small seta distally. The 1st basal segment bears a row of hairs.

The mandible possesses a strong biting ramus, the anterior tooth of which is elongate and sickle-shaped, as in *P. obtusa.*

In the 1st maxilla (Text-fig. 21, D) the various lobes bear the following number of setæ :

Inner Lobe 1,	15.
,, 2,	5.
,, 3,	4.
2nd basal,	5.
Endopod,	4, 4 and 7.
Exopod,	10.
Outer Lobe,	7, plus 2 smaller posterior ones.

In the maxilliped the proportional lengths of the various segments are as 42, 65 and 21, so that the 2nd basal segment is 1·55 times as long as the proximal segment, and 3·1 times the length of the endopod.

The 1st leg agrees with the description given by With (*loc. cit.*, p. 149).

In the 2nd leg the endopod is composed of a single segment, that shows no trace of any division into two segments.

The number of teeth on the terminal spine of the exopod of the 3rd leg is considerably less than in the 2nd and 4th legs, and these teeth are larger and coarser ; in the 2nd and 4th legs this spine bears 57 or 58 teeth, whereas in the 3rd leg there are only 42.

The basal segment of the 4th leg is devoid of any row of spines, and is even without a row of hairs on its inner margin.

Distribution.—This species has now been recorded from the Antarctic (lat. 66° 30′–76° S. (Farren), the Arabian Sea (present record), the North Atlantic Ocean (Sars), the west coast of Ireland (Farren), south of Iceland (lat. 60° 30′ N., long. 17° 08′ W.) (With) and in Davis Straits, W. Greenland (Jespersen).

Pseudochirella obtusa Sars.

Undeuchæta obtusa, Sars, 1905, p. 13; Lysholm and Nordgaard, 1921, p. 17.
Pseudochirella obtusa, Sars, 1925, p. 83, pl. xxiv, figs. 1–4; Sewell, 1929, p. 131, text-fig. 50, *a–d*.
Euchirella dubia, A. Scott, 1909, p. 60, pl. xiv, figs. 1–7.
Chirudina abyssalis, With, 1915, p. 147, text-fig. 40, *a–c*, pl. v, figs. *a–f*.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female, adult.

Descriptive Notes.—♀. Total length, 5·75 mm.

This agrees closely with the size of Sars's specimens from the North Atlantic Ocean, which measured 5·8 mm. A. Scott gives the length of his specimens from the Malay Archipelago as 7·0 mm. The proportional lengths of the cephalothorax and abdomen are as 78 to 22. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
397	135	88	73	50	31	91	50	35	21	29 = 1000

The line of fusion of the cephalon and 1st thoracic segment is clearly visible in stained specimens and the fusion appears to be incomplete dorsally.

The rostrum is a stout single process that is slightly curved posteriorly. The forehead is devoid of any crest. The 4th and 5th thoracic segments are separate and the posterior thoracic margin is rounded. The genital segment is symmetrical; on either side about the middle of its length there is a slight rounded protuberance. All the abdominal segments are hairy. The furcal rami are as broad as long.

The 1st antenna reaches back to the anal segment. The proportional lengths of the various segments are as follows:

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
67	42	27	27	29	31	31	49	28	28	28	45	45	50	52	55	49	65

20.	21.	22.	23.	24.	25.
61	42	49	51	38	11 = 1000

The 8th and 9th segments are fused, but the 24th and 25th are, at least partially, separate.

In the 2nd antenna the endopod is well developed, and the proportional lengths of the two rami are as 28 to 47; the endopod thus reaches to a little beyond the middle of the length of the exopod. Segments 1 and 2 of the endopod are separate. There is a row of hairs on the 1st basal segment.

In the mandible the biting ramus is well developed and the most anterior tooth is elongate and sickle-shaped. The 2nd basal segment bears three setæ, of which the proximal is much the stoutest.

In the 1st maxilla the 2nd inner lobe bears 5 setæ and the 3rd carries 4; the 2nd basal segment bears 4 setæ and the endopod 15 (4 + 4 + 7); the exopod bears 11 setæ and the outer lobe 9, the proximal two being small and delicate.

In the maxilliped the proportional lengths of the two basal segments are as 5 to 8. The anterior margin of the 1st basal segment is produced distally in a bluntly rounded eminence that is covered with small spinules; on the distal border is a nipple-like prominence, similar to that present in *C. notacantha*.

In the 4th leg there is a considerable degree of variation in the number of spines arising from the 1st basal segment, to which I have already called attention (*vide* Sewell, 1929, p. 132). In the present specimen there were 6 spines on one side and 8 on the other. The range of variation thus seems to extend from 6 in the present specimen to 13 (*vide* Jespersen, 1934, p. 65).

Distribution.—This species would appear to have a wide distribution. A. Scott has recorded it (as *Euchirella dubia*) from the Malay Archipelago ; I have recorded it from the Laccadive Sea, and the present record extends its distribution in the Indian Ocean to the Arabian Sea. Sars and Rose have recorded it from the North Atlantic Ocean, Farran off the west coast of Ireland, Lysholm and Nordgaard (as *Undeuchæta obtusa*) from lat. 56° N., With (as *Chirudina abyssalis*) from the North Atlantic as far as lat. 61° 30′ N., and Jespersen from the waters south of Davis Strait.

Genus *Undeuchæta* Giesbrecht.

Undeuchæta, Giesbrecht, 1888, p. 335 ; 1892, p. 54.

As I have previously pointed out (Sewell, 1929, p. 123), a number of species have from time to time been referred to this genus, and have subsequently been removed ; at present the various forms that can definitely be placed in this genus are as follows :

Undeuchæta australis (Brady).
U. bispinosa Esterly.
U. incisa Esterly.
U. intermedia A. Scott.
U. major Giesbrecht.
U. minor Giesbrecht.
U. plumosa (Lubbock).

Some of the above are undoubtedly synonyms. As Sars (1925, p. 81) has pointed out, *Undeuchæta minor* Giesbrecht (1892) is indubitably the same as the form previously described by Brady (1883) under the name *Euchæta australis*, and A. Scott (1909, p. 62) has called attention to the fact that *Undeuchæta plumosa* (Lubbock, 1856), described from the male, is a synonym of the same form ; thus the correct name of the species must be *Undeuchæta plumosa* (Lubbock). It also appears to me highly probable that *Undeuchæta incisa* Esterly (1911, p. 319) is identical with the form described by With (1915, p. 137) under the name *Undeuchæta superba*, but Esterly's account is very incomplete ; if this be so, then this species must be transferred to the genus *Pseudochirella*, to which Jespersen has already transferred With's species. It seems to me by no means improbable that the species described by Wolfenden (1911, p. 244, pl. xxix, figs. 4–7) under the name *Mesundeuchæta asymmetrica* will also eventually prove to be the same species. In the presence of a crest, the asymmetrical development of the posterior thoracic margins and the presence of a prominence on the right side of the genital segment, it agrees with the accounts of *Undeuchæta incisa* and *U. superba*. With (1915, p. 141) has pointed out that the reasons adduced by Wolfenden for the creation of a new genus are quite insufficient.

A. Scott (1909, p. 61) has expressed the opinion that the male described by Thompson (1903, p. 21, pl. iii, figs. 1–5) under the name *Scolecithrix cristata* Giesbrecht is in reality

the male of *Undeuchæta major* Giesbrecht, and With (1915, p. 137) accepts and agrees with this view: it seems to me, however, that both these authors are wrong. Sars (1925, p. 81) has described and figured the true male of *U. major*, and Thompson's male appears to me to be the male of *Euchirella curticauda* Giesbrecht.

At the present time this genus thus includes five species that can be separated into two groups as follows:

1. Those in which a frontal crest is present, and the genital segment of the female is devoid of any spine or rod-like projection in the dorso-lateral region on the right side.

   Undeuchæta major Giesbrecht.
   Undeuchæta incisa Esterly (= *U. superba* With).

2. Those in which the frontal crest is reduced to a mere trace or is altogether absent, and a spine or rod-like projection is present in the dorso-lateral region of the right side of the genital segment in the female.
   (*a*) There is a trace of a frontal crest, and a spinous projection is present on the righ tside of the genital orifice of the female:

   Undeuchæta intermedia A. Scott.

   (*b*) There is no spinous projection on the right side of the genital aperture of the female:

   Undeuchæta plumosa Lubbock (= *U. australis* (Brady) and *minor* Giesbrecht).

   (*c*) A spinous projection is present on the right side of the genital orifice of the female and a smaller spine on the left side of the orifice:

   Undeuchæta bispinosa Esterly.

The genus would appear to be primarily an Indo-Pacific one, for no less than four of these species have been recorded from the San Diego region of the Californian coast, namely *U. incisa*, *bispinosa*, *major* and *plumosa*, and of these the first three also occur in the Indian Ocean, while *intermedia* is known, at present, only from the Malay Archipelago; three species, *incisa*, *major* and *plumosa*, are known from the Atlantic Ocean, in which *minor* extends as far north as lat. 61° 30′ N.

In the present collection only two species are represented, namely *U. bispinosa* Esterly and *U. major* Giesbrecht.

Undeuchæta bispinosa Esterly.

Undeuchæta bispinosa, Esterly, 1911, p. 318, pl. xxvi, fig. 4, pl. xxix, figs. 48, 56; Sewell, 1929, p. 124, figs. 47 *a–e* and 48 *a–d*.

Occurrence:

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female, adult, 1 male, adult, and 3 juv.

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 8 females, adult.

Sta. 145 C, Maldive area, 50–0 m., 2 juv.; 500–0 m., 10 females, adult.

Sta. 145 D, Maldive area, 300–0 m., 3 females, adult, 2 males, juv.; 500–0 m., 8 females, adult, 1 juv.

Sta. 172, Central part of Arabian Sea, 400–0 m., 19 females and 1 male; 850–0 m. 56 females, adult, and 1 male.

Sta. 186, Gulf of Aden, 600–0 m., 6 females.

Distribution.—In the Indo-Pacific region; from the San Diego region of the Californian coast (Esterly), the Bay of Bengal and Laccadive Sea (Sewell), and the Maldive

region, central and southern areas of the Arabian Sea and the Gulf of Aden (present records).

The vertical distribution would appear to range from about 300 metres down to at least 1000 metres, with a maximum at about 500 metres. Young stages may occur much nearer the surface at 50 metres depth.

Undeuchæta major Giesbrecht.

Undeuchæta major, Giesbrecht, 1892, p. 228, pl. xxxvii, figs. 56, 57, 59 ; van Breemen, 1908, p. 43, fig. 49 ; Wilson, 1932, p. 60, fig. 39, *a–d* ; Sars, 1925, p. 81, pl. xxiii, figs. 7–12.
Chirundina angulata, Sars, 1905*a*, p. 13 ; 1907, p. 3.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female.

Distribution.—This species has been taken in the Pacific Ocean off the Californian Coast in the San Diego region (Esterly), in the North Pacific region (Giesbrecht), and in the Malay Archipelago (A. Scott). In the Indian Ocean it has been taken in the Indian Ocean and Bay of Bengal (Thompson), the Arabian Sea (Thompson and A. Scott, present record), the Gulf of Suez (Thompson), and the Agulhas current (Cleve). In the Atlantic Ocean it occurs in the South Atlantic and the adjacent part of the Indian Ocean (Wolfenden), the North Atlantic (Sars, Lysholm and Nordgaard), the west coast of Ireland (Farran), in the Gulf of Maine (Bigelow) and the Woods Hole region (Wilson), and in the area to the south of Iceland, the Iceland–Faroe Channel, and in Denmark Strait (With).

As regards the depth distribution, this species has been taken on the surface in both the Atlantic and Indian Oceans ; its main centre of occurrence is, however, to be found between 550 and 2000 metres.

Genus *Pseudeuchæta* Sars.

Pseudeuchæta, Sars, 1905*a*, p. 19 ; Sars, 1925, p. 102.
Autanepsius, Wolfenden, 1911, p. 350.

The genus *Pseudeuchæta* was created by Sars to accommodate a new species that he discovered in the North Atlantic, *P. brevicauda*, and he considered that the genus was closely related to *Euchæta*, and therefore placed it in the Family Euchætidæ. Farran (1906, p. 31) has, however, concluded that the genus " is in reality closely allied to *Bradyidius*, *Bradyetes* and *Bryaxis*," and therefore he has removed the genus from Euchætidæ and placed it in Ætideidæ. Wolfenden in 1911 described a genus *Autanepsius* to accommodate two species, namely *A. major* and *minor*, that were taken by the " Gauss " in the tropical part of the Atlantic Ocean. He is of the opinion that this genus should be placed in the family Augaptilidæ near *Augaptilus* and *Pontoptilus*.

In the present collection I have found a single adult female and a young male in Stage V, which agree so closely with Sars' *Pseudeuchæta brevicauda* and Wolfenden's *Autanepsius minor* that I am unable to discover any valid difference between them, and I am convinced that these two species are identical, Sars' name having priority ; Wolfenden's genus *Autanepsius* must be regarded as a synonym of *Pseudeuchæta*. A comparison of the characters of this species with those of the genera named by Farran has convinced me that he is right, and that the genus *Pseudeuchæta* must be placed in the Family Ætideidæ near *Bradyetes* and *Bryaxis*. In the following Table I have given the corresponding characters in these genera :

Bradyetes Farran.	*Pseudeuchæta* Sars.	*Bryaxis* Boeck.
Cephalon and 1st thoracic segment imperfectly separated.	ditto.	Cephalon and 1st thoracic segment fused.
Cephalon deeply inflexed in lateral margin.	ditto.	ditto.
Rostrum absent.	Rostrum absent or greatly reduced.	Rostrum absent.
Thoracic segments IV and V coalesced.	Thoracic segments IV and V incompletely fused.	Thoracic segments IV and V fused.
Posterior thoracic margin rounded.	Posterior thoracic margin rounded or produced in small blunt points.	Posterior thoracic margin pointed.
Abdomen (♀) of four segments: furcal rami slightly longer than broad.	Abdomen (♀) of four segments: furcal rami comparatively short.	Abdomen (♀) of four segments: furcal rami short.
Accessory furcal seta small.	ditto.	ditto.
1st antenna of 24 segments: strong, ringed setæ on joints 1, 2, 7, 13, 17, 20, 21, 22, 23 and 24.*	1st antenna of 24 segments: strong, ringed setæ on joints 3, 7, 8, 13, 15, 17, 20, 22, 23 and 24.*	1st antenna of 24 segments: all segments with strong ciliated setæ.
2nd antenna with exopod longer than endopod; exopod of 7 segments, segments 1 and 2 with papillæ bearing small setæ.	2nd antenna with exopod and endopod nearly equal; exopod of 7 segments, segments 1 and 2 with papillæ bearing small setæ.	2nd antenna with exopod poorly developed: exopod of 6 segments.
Mandible with endopod smaller than exopod.	ditto.	Mandible with endopod much smaller than exopod.
1st maxilla with very small exopodite.	ditto.	ditto.
2nd maxilla ?	Lobes 1–4 fringed with spinules: lobe 5 longer than others; setæ on lobe 5 not much thicker than the rest.	Lobes 1–4 with terminal group of spinules: lobe 5 longer than others, one seta on lobe 5 much thickened.
Maxilliped not markedly elongate; last 5 joints very short.	Maxilliped markedly elongate; last 5 joints very short; sausage-shaped sensory organ at end of 1st basal.	Maxillipeds largely developed; sausage-shaped sensory organ at end of 1st basal.
1st leg: exopod of 3 joints, endopod of 1 joint; exopod 1 with 1 inner seta and a marginal spine.	1st leg: exopod of 3 joints, endopod of 1 joint; exopod 1 without a marginal spine.	1st leg: exopod of 3 joints, endopod of 1 joint; exopod 1 with 1 inner seta and a marginal spine.
2nd leg: exopod of 3 segments, endopod of 2 segments; marginal spine of exopod 2 long.	ditto.	ditto.
3rd and 4th legs both with exopod of 3 joints and endopod of 3 joints.	ditto.	ditto.
5th leg absent.	5th leg greatly reduced or absent.	5th leg absent.

* These numbers correspond to the free joints and not to the segments, segments 8 and 9 being fused in all three genera.

In *Bradyetes* and *Bryaxis* the spines arising from the endopod of the maxilliped are normal, whereas in *Pseudeuchæta* these spines are armed with numerous small crescent, or half-moon shaped, lamellæ set transversely along the length of the seta. Sars makes no mention of these lamellæ in his account, and merely figures the setæ as being strongly

denticulated, but Wolfenden, in his account of *Autanepsius*, calls attention to them and accurately figures them in *A. minor*. They are very difficult to see in mounted specimens owing to their refraction.

There can thus be but little doubt of the very close relationship between these three genera; indeed, so close is the resemblance between *Bradyetes* and *Pseudeuchæta* that they might almost be combined into one.

Pseudeuchæta brevicauda Sars. (Text-fig. 22, A–J.)

Pseudeuchæta brevicauda, Sars, 1905, p. 18; Sars, 1925, p. 102, pl. xxix, figs. 1–12.
Autanepsius minor, Wolfenden, 1911, p. 252, text-fig. 80 *a*, *b*, pl. xxxviii, figs. 9, 10.

Occurrence.—Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 female, 1 male, juv.

Descriptive Notes.—♀. Total length, 4·80 mm. This is the same length as Wolfenden's example, and somewhat smaller than Sars' specimen from the North Atlantic. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
402	118	94	67	57	27	94	47	37	27	30 = 1000

The cephalon tapers towards the anterior end and there is no trace of any rostrum; the lateral margin is markedly inflexed as in *Bradyetes*. The line of fusion of the cephalon and the 1st thoracic segment is clearly visible in the dorsal region. The 4th and 5th thoracic segments are only partially fused, the line of fusion being clear. The posterior thoracic margin is produced backwards in a small flap that is slightly prominent at its extreme apex, as figured by Wolfenden (1911, pl. xxxviii, fig. 9). The genital segment is somewhat expanded, and the genital orifice is situated on a slight swelling that is divided transversely by a groove: in length the segment is nearly equal to the following three segments together.

The 1st antenna (Text-fig. 22, A) reaches back to about the end of the cephalothorax: segments 8 and 9 are fused, but 24 and 25 are separate. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	70	70	33	29	31	29	29	52	31	31	31	43	43	43	43	43	43	43

20.	21.	22.	23.	24.	25.
40	43	45	57	48	29 = 1000

The 1st and 2nd segments are of equal length, and are considerably longer than any of the following segments. Segments 3, 7, 9, 14, 16, 18, 21, 23, 24 and 25 all bear long ringed setæ, as in *Bradyetes inermis* Farran. These numbers do not apparently tally with those given by Wolfenden or Farran, but these authors count the fused 8th and 9th segments as one, so that from the 9th segment on to the tip the above numbers are one more than theirs. The 23rd segment is considerably longer than the segment before or beyond it.

In the 2nd antenna (Text-fig. 22, B) the two branches are of approximately equal length. The outer ramus is composed of 7 segments; of these the 1st is produced on its

anterior margin in two small prominences, from each of which arises a small seta, and the 2nd segment also carries one such projection near the proximal end, thus being very similar to the condition seen in *Bradyetes inermis* Farran.

TEXT-FIG. 22.—*Pseudochirella brevicauda* Sars, ♀. A, 1st antenna. B, 2nd antenna. C, Mandible. D, 1st maxilla. E, 2nd Maxilla. F, maxilliped. G, 1st leg. H, 2nd leg. I, 3rd leg. J, 5th pair of legs. ♂ Stage V.

In the mandible (Text-fig. 22, C) the biting ramus is provided with very strong teeth ; the 2nd basal segment bears a single seta. The rami are of very unequal length, the exopod being much longer than the endopod. In the latter the 2nd segment bears 8 setæ and the 1st only one.

In the 1st maxilla (Text-fig. 22, D) the various lobes bear the following numbers of setæ :

The 1st inner lobe	13
,, 2nd ,, ,, ...	4
,, 3rd ,, ,, ...	3
,, 2nd basal	5
,, 1st segment endopod	4
,, 2nd ,, ,, ...	4
,, 3rd ,, ,, ...	6
,, exopod	10
,, outer lobe	8

This agrees with the numbers given by Wolfenden in *Autanepsius minor*. The longer setæ arising from the endopod are finely denticulated, as was pointed out by Sars, and so also are the longer setæ on Basal 2. The exopod is small, as in *Bradyetes*.

In the 2nd maxilla (Text-fig. 22, E) the 5th lobe is considerably longer than the others ; the 2nd, 3rd and 4th lobes are fringed with fine spines. Each lobe bears 3 setæ ; according to Wolfenden the 5th lobe bears only 2 setæ in *Autanepsius minor*.

In the maxilliped (Text-fig. 22, F) the proportional lengths of the various parts are as follows :

1st basal segment	41
2nd ,, ,, ...	44
Endopod	15

Wolfenden's measurements in *Autanepsius minor* are given as 22, 22 and 9, which correspond to 41·5, 41·5 and 17 : there is thus a very close agreement. The setæ arising from the segments of the endopod are armed with a number of closely-placed, crescentic plates, exactly as figured by Wolfenden (1911, text-fig. 80 *a*). These setæ are long, and taper to a delicate point. The 2nd basal segment bears at its distal end a blunt, sausage-shaped sensory organ, similar to that in *Bryaxis*.

The swimming legs (Text-fig. 22, G, H, I) agree exactly with the description and figures given by Sars.

Both Sars and Wolfenden state that the 5th pair of legs is absent. In the present specimen there is a very small rudimentary pair of 5th legs, composed of a basal plate and, on each side, a small ramus, composed of two very small, almost globular segments, that are entirely devoid of setæ.

Accompanying this female was a single immature male.

♂. *Stage V*. Total length, 3·89 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
400	120	86	86	47	21	43	64	47	43	43 = 1000

The forehead resembles that of the adult female and is devoid of a rostrum. The posterior thoracic margin is produced back in a small flap that terminates in a bluntly pointed apex, below which there is a small notch in the margin.

The cephalic appendage and the first four pairs of legs resemble those of the female.

A rudimentary 5th pair of legs (Text-fig. 22, J) is present, and each consists of a two-jointed basal part and a single-jointed endopod and exopod. The former is indented in about the first third of its length, clearly denoting where the segmentation into two segments will be formed at the next moult; on the outer margin at this indentation there is a small spine. In the left leg the exopod terminates in a long, well-developed spine that is more than half the length of the segment; the outer border bears a small spine distally and two small spines on the inner border. In the right leg the exopod bears a small spine distally and a minute one at the distal outer angle. Both the endopods are short and have rounded extremities. At this stage the limb closely resembles that of an immature *Gætanus* (*vide* With, 1915, text-fig. 27*e*, in *Gætanus latifrons*) and *Euchirella* (*vide* With, 1915, text-fig. 33 *h*, in *Euchirella maxima*).

Distribution.—The North Atlantic to the south of Davis Strait (Jespersen), off the Irish coast (Farran) and at several stations in the eastern region (Sars). As *Autanepsius minor*, it has been recorded from the Equatorial region of the Atlantic by Wolfenden. The present record extends its distribution to the Arabian Sea.

Genus *Valdiviella* Steuer.

Valdiviella, Steur, 1904, p. 593; Sewell, 1929, p. 133.

There has been in the past some divergence of opinion regarding the correct systematic position of this genus. Steuer, who created the genus, suggested that it ought to be included in the family Ætideidæ, but Sars (1905) and Wolfenden (1911) consideerd the genus to be closely related to Euchæta, and place it in the Euchætidæ. A. Scott (1909) agreed with this view, and in a previous paper (Sewell, 1929) I followed Scott and included the genus in the Euchætidæ. With (1915), however, agrees with Steuer, and remarks, "With some right Steuer suggests that it (the genus *Valdiviella*) ought to be referred to the Ætideidæ; the structure of the legs, of the labrum, the labium and the antennulæ support this view." Further evidence of the truth of this conclusion is to be found in the mouth parts, which much more nearly agree with those of some of the Ætideidæ than with the Euchætidæ. Thus the mandibular palp bears on the 2nd basal segment two setæ, of which the proximal is the longer, thus closely resembling the conditions found in *Pseudochirella* and most of the species of *Gætanus*: 1st and 2nd maxillæ resemble those of the Ætideidæ. The 5th leg of the male also closely resembles, in its general type, the appendage in *Gætanus* and *Chirundina*, and differs markedly from that of either *Euchæta* or *Paraeuchæta*. I am therefore of the opinion that *Valdiviella* must be included in the family Ætideidæ.

Valdiviella insignis Farran.

Valdiviella insignis, Farran, 1908, p. 45, pl. iii, figs. 1–6, pl. iv, fig. 5; Wolfenden, 1911, p. 247, pl. xl. figs. 6, 7; With, 1915, p. 154, text-fig. 44, *a–d*, pl. vi, fig. 2, *a–e*; Sars, 1925, p. 98, pl. xxvii, figs, 1–16, pl. xxviii, figs. 1–10; Sewell, 1929, p. 135, text-fig. 51.

Occurrence.—Sta. 172, Central part of Arabian Sea, 2091–0 m., 2 females.

Remarks.—These examples agree closely with the description and figures given by previous workers. The total length was about 11·5 mm. As With (1915, p. 155) has pointed out, there appears to be some variation in the number of setæ that are carried by the outer lobe of the 1st maxilla; Farran states that in his examples from the west

coast of Ireland there were 7, and Sars figures this number in his examples ; With, however, found only 6 in his specimen from the North Atlantic, and in the example from the Arabian Sea dissected by me there are only 5.

DISTRIBUTION.—This species has now been taken in the North Atlantic as far north as lat. 61° 30′ N. (With), off the coast of Ireland (Farran), in the temperate region (Lysholm and Nordgaard), and between the Azores and Canary Islands and Gibraltar (Sars) ; in the tropical part of the South Atlantic (Wolfenden) ; and in the Arabian Sea (present record) and the Bay of Bengal (Sewell).

Valdiviella oligarthra Steuer.

Valdiviella oligarthra, Steuer, 1904, p. 593, figs. 1–3 ; Sewell, 1929, p. 140, text-fig. 54, *a*, *b*.

OCCURRENCE.—Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 female.

REMARKS.—The total length of this example was almost exactly 10·0 mm., which is slightly larger than Steuer's original example, which measured 9·0 mm., and considerably larger than the examples previously taken in Indian waters, which measured only 7·2 mm.

In this species, as in *V. insignis* Farran, there is a tendency for the number of setæ arising from the outer lobe of the 1st maxilla to vary ; Steuer states that the number is 7, but that in some specimens the 1st and 2nd may be wanting. In the present example all 7 were present.

DISTRIBUTION.—Off the west coast of Africa (Steuer), in the tropical and northern Atlantic Ocean (Wolfenden), in the Arabian Sea, northern area (present record), near the Seychelles (Steuer), and in the Laccadive Sea and Bay of Bengal (Sewell).

Family EUCHÆTIDÆ.

Genus *Euchæta* Philippi.

A number of species originally attributed to this genus have since been separated off by A. Scott (1909, pp. 64 and 69) in a new genus that he named *Paraeuchæta*. In the female in the genus *Euchæta* some of the six spines that spring from the terminal or endopod portion of the 2nd maxilla (or 1st maxilliped, as A. Scott terms it) are provided with long spinules, whereas in *Paraeuchæta* none of the spines are armed with these long spinules : in the male the 3rd segment of the exopod of the left 5th leg is produced in a long spiniform process in *Euchæta*, whereas in *Paraeuchæta* this 3rd joint is short and rudimentary. Sars (1925, p. 104) has followed A. Scott in separating these two genera, and he has added a further distinguishing character, namely the form of the accessory setæ of the furcal rami : in *Euchæta* these accessory setæ are much more strongly developed than the other furcal setæ, whereas in *Paraeuchæta* they are always very slender and are of a different shape, arising from a small conical prominence at the inner distal angle of the ramus and exhibiting a well-marked " knee-joint " not far from the base.

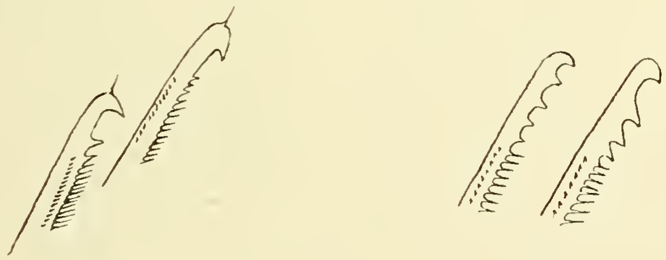
A further point of difference is to be found in the character of the distal end of the long spines arising from the endopod of the maxilliped : in those species that have been referred to the genus *Euchæta* each spine terminated in a minute bifurcation, one branch

of which forms a recurved tooth, while the other forms a delicate, tapering, short flagellum. This type (Text-fig. 23, A) has been recognized in the following :

Euchæta consimilis Farran.
E. marina (Prestand.).
E. media Giesbr.
E. spinosa Giesbr.
E. tenuis Esterly.
E. wolfendeni A. Scott.

In the case of the females of those species that have been referred to the genus *Paraeuchæta*, these spines terminate in a rounded end without any flagellum, and the distal part of the inner margin is armed with a row of three or four comparatively stout teeth, forming a comb (Text-fig. 23, B). This character has been seen in—

Paraeuchæta investigatoris Sewell.
P. malayensis Sewell.
P. weberi A. Scott.



A B

TEXT-FIG. 23.—The tips of the terminal spines of the maxilliped in A, *Euchæta* and B, *Paraenchæta*.

With (1915, p. 157) is, however, doubtful whether the distinction between these two groups of species is really a valid one, and he points out that in *Euchæta hebes* Giesbrecht, in which the 5th leg of the male conforms to the type of Scott's genus *Paraeuchæta*, one of the apical setæ of the 2nd maxilla is armed with long spinules, as in the genus *Euchæta* (*sensu stricto*). He also points out that in *Euchæta acuta* Giesbrecht also only a single such spine is present. It thus appears that *Euchæta hebes* Giesbrecht forms a connecting link between the two groups *Euchæta* and *Paraeuchæta*, but this seems to me to be hardly sufficient grounds for refusing to recognize the two genera.

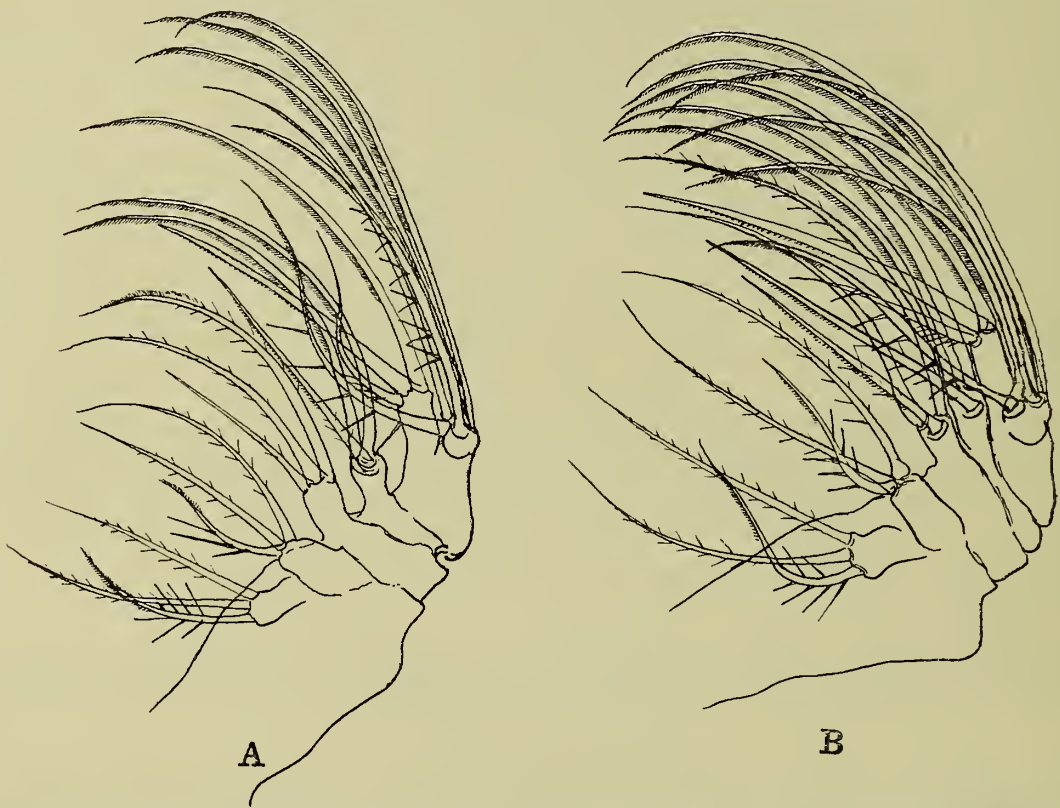
A careful examination of those species in the present collection that can be referred to this genus has revealed that they can be subdivided into two groups, according to whether the terminal part of the 2nd maxilla bears only one spine that is provided with long lateral spinules, or two such spines.

In Group I, of which *Euchæta marina* (Prestand.) may be taken as the type, two of the apical spines are armed with long spinules (Text-fig. 24, A). To this Group may be referred *Euchæta marina* (Prestand.) and *Euchæta wolfendeni* A. Scott.

In Group II only a single spine arising from the endopod of the 2nd maxilla is furnished with lateral spinules (Text-fig. 24, B), and in this Group must be included the following :

Euchæta acuta Giesbrecht.
E. concinna Giesbrecht.
E. consimilis Farran.
Euchæta media Giesbrecht.
E. spinosa Giesbrecht.
E. tenuis Esterly.
Euchæta murrayi sp. nov.

Euchæta hebes Giesbrecht forms a connecting link between this Group and the genus *Paraeuchæta* A. Scott.



Text-fig. 24.—The 2nd maxilla in *Euchæta*. A, In species belonging to Group I. B, In species belonging to Group II.

Group I.—Both species of this group, *Euchæta marina* and *E. indica* Wolfenden, were present in the collection that Wolfenden examined from the Maldive and Laccadive Archipelagos : unfortunately in his account of *E. indica* Wolfenden, as A. Scott (1909, p. 67) has pointed out, gave a wrong description of the 2nd leg, the account being apparently taken from the corresponding appendage of *E. marina*. He further complicated matters by incorrectly naming the figures which illustrated his account ; thus in pl. C, figs. 12–16, which are labelled *Euchæta indica*, are clearly drawn from *E. marina*, while figs. 7, 8, 10, 11, 17 and 18, labelled *Euchæta marina* ♀, actually refer to *E. indica*. A comparison of Wolfenden's figures and those given by A. Scott in his account of *E. wolfendeni* leaves no doubt that the two forms are identical, but to avoid further confusion I have adhered to the name given by A. Scott.

Group I.

Euchæta marina (Prestandrea). (Text-fig. 25, A–D.)

Euchæta marina, Giesbrecht, 1892, p. 246, pl. i, figs. 10–11, pl. xv, figs. 31, 33, pl. xvi, figs. 15–17, 22, 23, 25, 29, 30, 41, 46, pl. xxxvii, figs. 30, 37, 38, 49 ; A. Scott, 1909, p. 67, pl. xix, figs. 9–20.
Euchæta marina, Wolfenden, 1906, p. 1008, pl. c, figs. 19, 20.
Euchæta indica, Wolfenden, 1906, pl. c, figs. 12–16.

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, surface, 1000–0 m., 18 females ; 1500–0 m., 38 females, 3 males ; 2000–0 m., 1 female, 2 males.

Sta. 61 C, Northern part of Arabian Sea, surface, 1205 examples ; 1000–0 m., 104 females, 12 males ; 1500–0 m., 40 females, 2 males.

Sta. 76, Gulf of Oman, 200–0 m., 4 females ; 600–0 m., 1 female.

Sta. 96, Central part of Arabian Sea, 10 m., 6 females, 1 male ; 645–400 m., 78 females, 3 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m. vertical, 76 females, 2 males ; 1500–0 m. vertical, 36 females, 7 males.

Sta. 145 C, Maldive area, 50–0 m. vertical, 7 females, 1 male ; 300–0 m. vertical, 7 females ; 500–0 m. vertical, 4 females, 1 male.

Sta. 145 D, Maldive area, 50–0 m. vertical, 3 females ; 100–0 m. vertical, 3 females ; 300–0 m. vertical, 1 female, 1 male.

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

Remarks.—This species appears to exhibit a considerable range of variation in size : Brady (1883, p. 60, under the name *E. prestandreæ*) gives the range as 3–5 mm. ; Giesbrecht (1892, p. 249) gives the range as 2·25 to 3·9 mm., and these dimensions are subsequently given by Giesbrecht and Schmeil (1898) and by van Breemen (1908). Wolfenden (1906, p. 1007) gives the length as 3·3 mm., and Wilson (1932, p. 64) gives the range as 2·25 to 4 mm. The present specimens, taken together at Sta. 61 in the northern area of the Arabian Sea, show a range from 3·0 mm. to 3·683 mm., the mean being 3·40 mm.

Although these specimens do not fall into groups, such as one would expect if there were more than one race or form present, there are, nevertheless, certain strucutral differences between the larger and smaller examples that appear worthy of notice.

The proportional lengths of the various segments of the body are as follows :

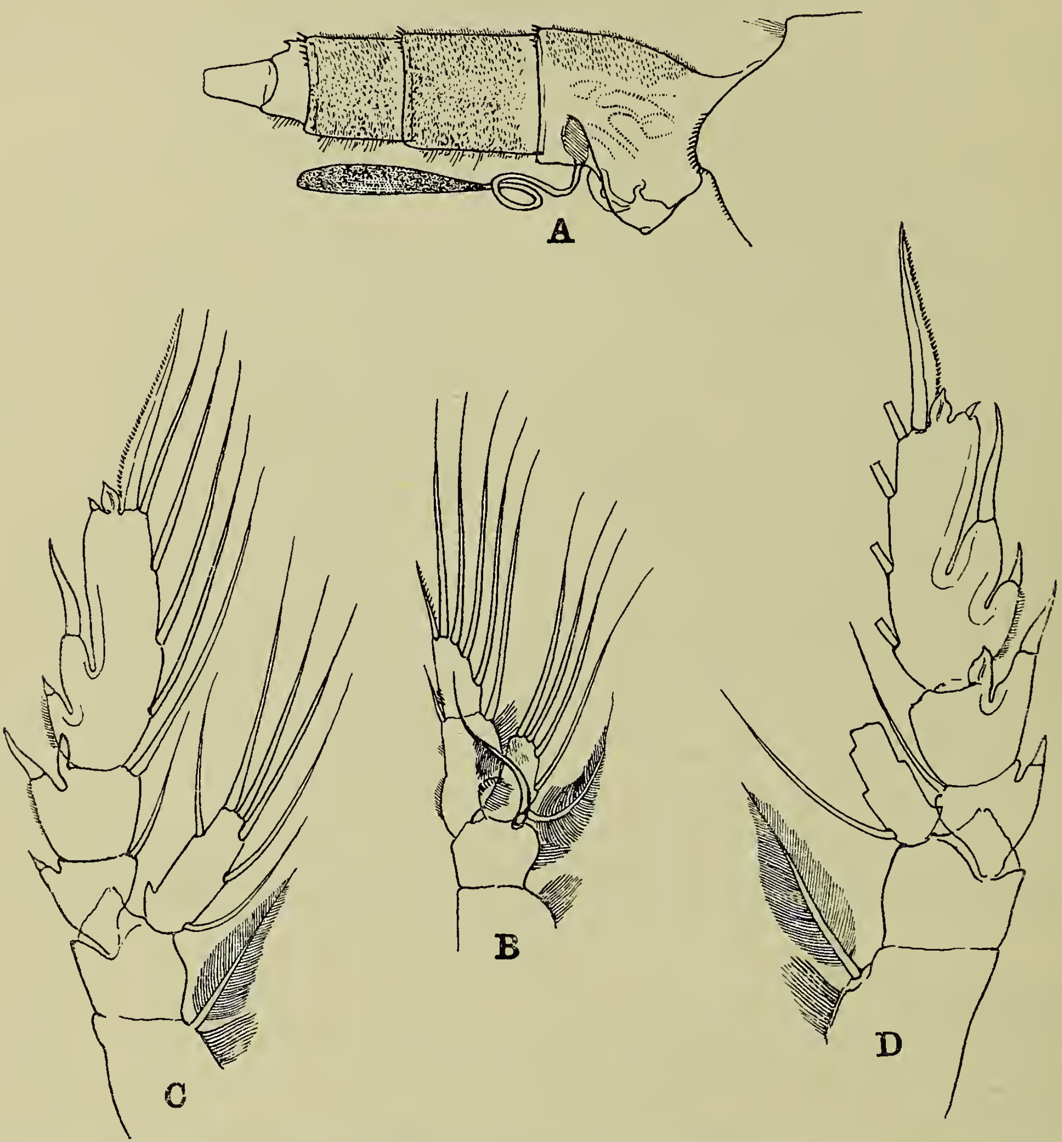
	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
Small example, 3·0 mm. .	319	115	84	84	89	120	68	53	26	42 = 1000
Large example, 3·683 mm.	307	118	90	77	95	127	68	50	27	41 = 1000

We thus have a slight reduction in the proportional length of the cephalothorax in the larger specimens, as compared with the smaller examples, and a slight change in the proportional lengths of the cephalothorax and abdomen, namely from 691 and 309 in the small, to 687 and 313 in the large—differences that agree closely with the change in the proportional lengths of the parts of the body in successive moults in a single species (*vide* Sewell, 1929).

There are also slight differences in the proportional lengths of the segments of the 1st antenna, as shown below :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.
Small specimen	58	36	16	16	21	22	24	34	20	22	30	38	40	43	54	54
Large specimen	62	38	17	17	21	22	25	36	21	22	32	38	41	46	56	54

Segment	18.	19.	20.	21.	22.	23.	24–25.	
Small specimen	57	70	67	62	70	64	80	= 1000
Large specimen	56	70	69	62	65	58	72	= 1000



Text-fig. 25.—*Euchæta marina* (Prestandrea), ♀. A, Abdomen, lateral view. B, 1st leg. C, 2nd leg in small form. D, 2nd leg in large form.

As in the different growth stages of a species, so here there appears to be evidence that in the larger form the segments of the proximal part of the appendage are larger than in the smaller form up to about the 17th–19th segments, and beyond this the distal segments become progressively smaller, the percentage decrease in the terminal three joints being 7·1, 9·4 and 10·0 per cent.

Differences can also be detected in the relative length of the 2nd spine on the external margin of the 3rd segment of the exopod of the 2nd foot (Text-fig. 25, C, D). In some specimens this spine reaches as far as the tip of the 3rd marginal spine, whereas in others it falls considerably short of the base of the 3rd spine, and this difference, too, appears to be associated with the size of the individual, for in specimens having an average total length of 3·50 mm. it reached the tip of the 3rd marginal spine, in specimens having an average length of 3·40 mm. it reached to the base of the 3rd spine, and in specimens having a length of 3·10 mm. it fell short of the base.

In one specimen the joint between the 1st and 2nd segments of the exopod of the 2nd leg was incomplete, and the part of the combined segment that represented segment 1 was devoid of an inner seta.

At Sta. 61, in the northern area of the Arabian Sea, in the month of November, the breeding season appeared to be in full swing. Many of the females were carrying egg-sacs, and the number of ova ranged from 7 to 15, with a mean of 11. In every case the ovigerous female was also bearing one or more spermatophores: the maximum number of these latter observed on any single female was 11. A few males were also found bearing a spermatophore in the clasping apparatus of the left 5th leg.

One example of a young male in the 5th Copepodid Stage was seen to be infected with a *Blastodinium*, probably *B. contortum* Chatton (*vide* Chatton, 1920, p. 175).

Distribution.—West coast of America between 26° S. to 20° N. (Giesbrecht), Pacific Ocean between 42° N. and 40° S. (Brady, as *E. prestandreæ*), the Aru Archipelago (Früchtl), the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean from the coast of Southern Burma (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Laccadive Sea (Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden and present records), the Arabian Sea (Thompson and A. Scott, present records), the Gulf of Oman (present record), the Persian Gulf (Pesta), the Red Sea and Gulf of Suez (Thompson and A. Scott, A. Scott), Durban Bay (Brady), the Agulhas Current (Cleve), and west of the Crozet Islands (Brady, as *E. prestandreæ*). In the Atlantic Ocean, west of Cape Colony (Cleve), in the South Atlantic (Wolfenden, Farran, T. Scott) to 35° S., in the Tropical Atlantic (Dana, T. Scott, Farran), Gulf of Guinea (T. Scott), North Atlantic (Cleve, T. Scott, van Breemen, Sars, Rose), Mediterranean Sea (Philippi, Giesbrecht, Thompson, Thompson and A. Scott), in the Adriatic Sea (Pesta), the Gulf of Maine (Bigelow), and in the Woods Hole region (Wilson).

Euchæta wolfendeni A. Scott.

Euchæta indica (♀), Wolfenden, 1906, p. 1007.
Euchæta marina, Wolfenden, 1906, pl. c, figs. 7, 8, 10, 11, 17 and 18.
Euchæta wolfendeni, A. Scott, 1909, p. 68, pl. xvii, figs. 1–12; Sewell, 1929, p. 153.

Occurrence:

Sta. 61 A, Northern part of Arabian Sea, surface, 960 examples; 1000–0 m., 6 examples; 1500–0 m., 14 females; 2000–0 m., 8 females, 2 males.

Sta. 61 C, Northern part of Arabian Sea, surface, 7086 specimens; 1000–0 m., 63 females, 8 males; 1500–0 m., 9 females.

Sta. 76, Gulf of Oman, 200 m., 11 females; 600 m., 5 females; 1500 m., 4 females.

Sta. 96, Central part of Arabian Sea, 10 m., 11 females, 1 male ; 635–390 m., 3 females.

Sta. 145 C, Maldive area, 50–0 m. vertical, 1 female.

Sta. 145 D, Maldive area, 50–0 m. vertical, 1 female.

Remarks.—Several examples from Sta. 61 are infected with a species of *Blastodinium*, apparently *B. contortum* Chatton (*vide* Chatton, 1920, p. 175). In some instances infection had occurred as early as the 3rd Copepodid Stage. In two examples the infection was double and the parasites exhibited the " forme supertordue " of Chatton (cf. Chatton, *loc. cit.*, figs. 96 and 97).

Distribution.—The Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), the Andaman Islands and Ganjam Coast of India (Sewell), the Ceylon Pearl Banks (Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden, present records) and the Arabian Sea (present records).

Group II.

Euchæta consimilis Farran.

Euchæta concinna (*non* Giesbrecht), Wolfenden, 1906, p. 1008, pl. c, figs. 1–6.
Euchæta consimilis, Farran, 1936, p. 90, fig. 6, *a* and *b*.

Occurrence.—Sta. 61 C, Northern part of Arabian Sea, surface, 3 females.

Descriptive Notes.—Farran has separated this species from *E. concinna* Giesbrecht on the grounds of the somewhat different shape of the genital segment of the female abdomen and its very slightly smaller size. The present examples agree exactly with the description and figures given by Wolfenden (*loc. cit.*) of the examples that he took to represent *E. concinna* Giesbrecht and those specimens that I obtained from the Bay of Bengal and Nicobar Islands (*vide* Sewell, 1929, p. 148), in which the characteristic projection of the right side of the genital segment was more pronounced.

Distribution.—The Australian Barrier Reefs (Farran), the Nicobar Islands and the Bay of Bengal (Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), and the Northern part of the Arabian Sea (present record).

Euchæta media Giesbrecht.

Euchæta media, Giesbrecht, 1892, p. 246, pl. xvi, figs. 13, 36, pl. xxxvii, figs. 39, 40 ; A. Scott, 1909, p. 66, pl. xx, figs. 10–18 ; Esterly, 1905, p. 160, fig. 25.

Occurrence :

Sta. 131 D, South area of Arabian Sea, 500–0 m. vertical, 2 females ; 1500–0 m. vertical, 1 female.

Sta. 172, Central part of Arabian Sea, 400–0 m., 5 females ; 850–0 m., 1 female.

Distribution.—The San Diego region of the Californian coast (Esterly), and the Pacific Ocean between long. 103° and 166° E. (Giesbrecht), off New Zealand and on the Australian Barrier Reefs (Farran), and in the Malay Archipelago (A. Scott). In the Indian Ocean it has been taken in the Nicobar Islands (Sewell) and in the Arabian Sea (present records).

Euchæta spinosa Giesbrecht.

Euchæta spinosa, Giesbrecht, 1892, pp. 246, 263, pl. xvi, figs. 12, 26, 34 ; pl. xxxvii, figs. 31, 34, 35 and 51 ; van Breemen, 1908, p. 52, fig. 58, *a*, *b* ; Sars, 1925, p. 104, pl. xxx, figs. 1–6.

Occurrence.—Sta. 172. Central part of Arabian Sea. 850–0 m., 1 female.

Remarks.—♀. Total length, 6·70 mm.

Distribution.—In the Pacific Ocean this species has been taken in the San Diego Region of the Californian coast (Esterly). In the Indian Ocean it has been reported from the Nicobar Islands (Sewell), off Ceylon (Thompson and A. Scott), and to the South of Cape Colony (Cleve). In the Atlantic Ocean and its offshoots it has been taken in the South Atlantic (Cleve, Stebbing), the North Atlantic region (Cleve, van Breemen, Rose), off the Azores and Canary Islands (Sars), in the Bay of Biscay (Farran), off Cape Cod (Sharpe), and in the Woods Hole region (Wilson), in the Mediterranean (Giesbrecht, Thompson and A. Scott), and the Adriatic (Pesta). Usually it is of rare occurrence.

Euchæta tenuis Esterly.

Euchæta tenuis, Esterly, 1906, p. 61, pl. ix, fig. 13, pl. x, figs. 29, 30 ; A. Scott, 1909, p. 68, pl. xix, figs. 1–8 ; Sewell, 1929, p. 149, text-fig. 58 *a–j*.
Euchæta solida, Esterly, 1911 *b*, p. 342, pl. xxvi, fig. 2, pl. xxviii, fig. 34, pl. xxx, fig. 78 (♂).

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 20 females.

Sta. 131 D, Southern area of Arabian Sea. 500–0 m. vertical, 1 female ; 1500–0 m. vertical, 4 females.

Sta. 145 C, Maldive Region, 500–0 m. vertical, 1 male.

Sta. 172, Central part of Arabian Sea, 200–0 m., 5 females, 2 males ; 400–0 m., 56 females, 15 males ; 850–0 m., 74 females, 5 males.

Sta. 186, Gulf of Aden, 575–0 m., 18 females, 3 males ; 950–0 m., 26 females, 2 males.

Distribution.—In the Pacific Ocean this species has been taken in the San Diego region of the Californian coast of America (Esterly), and in the Malay Archipelago (A. Scott). In the Indian Ocean it appears to be fairly widely distributed, having been taken in the Bay of Bengal (Sewell), the Maldive region, the Arabian Sea and the Gulf of Aden (present records).

Euchæta murrayi sp. nov. (Text-fig. 26, a–i.)

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 female.

Sta. 61 C, Northern part of Arabian Sea, 1000–0 m., 5 females ; 1500–0 m., 2 females.

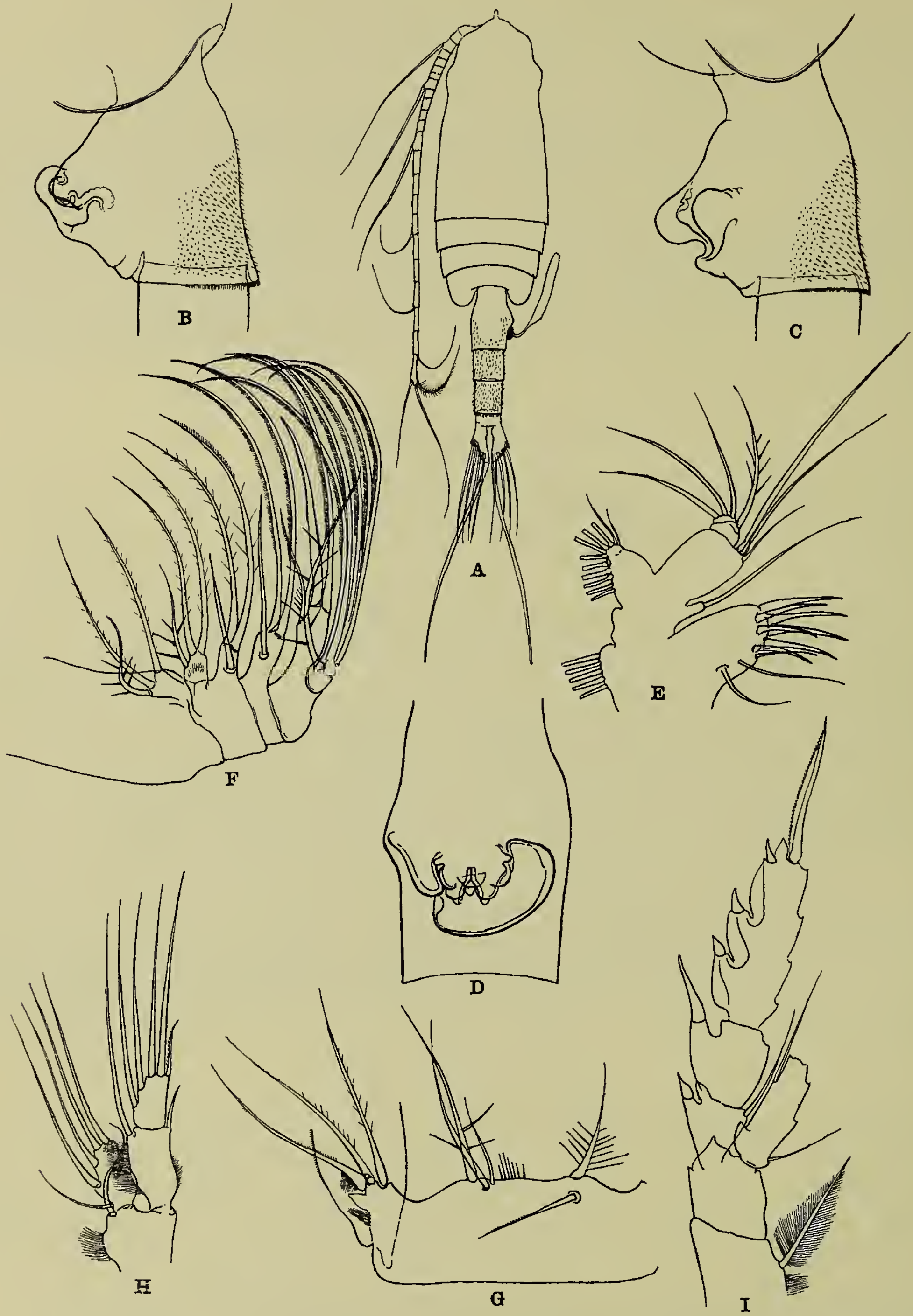
Sta. 76, Gulf of Oman, 600–0 m., 1 female ; 1500–0 m., 1 female.

Descriptive Notes.—♀. Total length, 2·58–2·78 mm.

The proportional lengths of the cephalothorax and abdomen are as 71 to 29. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
330	135	59	56	59	140	77	77	21	46 = 1000

The frontal eminence is prominent, as in *E. marina*, and the rostrum is well developed and points downwards and slightly forwards. The posterior thoracic margin is uniformly rounded.



TEXT-FIG. 26.—*Euchæta murrayi* sp. nov. ♀. A, Dorsal view. B, Genital segment, lateral view. C, Genital segment, lateral view. D, Genital segment, ventral view. E, 1st maxilla. F, 2nd maxilla. G, Basal segment of maxilliped. H, 1st leg. I, 2nd leg.

The genital segment (Text-fig. 26, B, C) is rather sparsely covered with short hairs on the dorsal aspect, and the dorsal part of the posterior margin is fringed with a row of

small spinules. The genital aperture is prominent ventrally and is situated in the posterior part of the segment; the aperture (Text-fig. 26, D) is bounded by, on the left side, a prominent rounded lamella, that commences at about the middle of the segment and is continued backwards and across the segment behind the vulva; on the right side is a smaller lappet. The 2nd and 3rd free segments of the abdomen are covered both dorsally and ventrally with numerous short hairs, and a few longer hairs arise from the ventral aspect of the 3rd segment. The furcal rami bear a number of short hairs on the ventral aspect. The accessory setæ are long, being about equal to the length of the whole body.

The 1st antenna reaches back to about the middle of the abdomen. It consists of the usual 23 free segments, that have the following proportional lengths:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	57	35	17	18	23	23	26	36	21	21	30	39	42	48	51	54	57	70

20.	21.	22.	23.	24–25.	
70	67	65	57	73	= 1000

The 8th and 9th segments are completely fused and the 12th and 13th partly so; the 24th and 25th segments are also fused. The 3rd, 7th, 9th, 14th, 18th, 21st, 23rd, 24th and 25th segments bear the usual long setæ.

In the 2nd antenna the 1st basal segment is provided with a row of hairs on the inner aspect. The two rami are of approximately equal length. The terminal segment of the endopod bears 6 and 7 setæ on the two lobes.

In the 1st maxilla (Text-fig. 26, E) the various lobes bear the following setæ:

Le. 1 . .	5 setæ, as in *E. marina* and *hebes*.
Li. 1 . .	10 setæ.
Li. 2 (or 3) .	1 seta.
B. 2 . .	1 long and 2 short setæ, as in *E. marina*, *acuta* and *spinosa*.
Ri. 1 . .	No seta.
Ri. 2–3 . .	1 + 3 setæ.

In the 2nd maxilla (Text-fig. 26, F) one of the spines, out of six, arising from the terminal lobe, presents the characteristic lateral spinules.

The maxilliped has the characteristic form of the genus. The spines arising from the endopod terminate in sharp points, without any trace of serrations. At the distal end of the 1st basal segment (Text-fig. 26, G) below the origin of the most distal spine is a short conical process, and below this is a tuft of hairs. The base of the seta immediately above this process is also hairy.

In the 1st leg (Text-fig. 26, H) the exopod is composed of two segments only, and the endopod of one. The outer border of the 1st segment of the exopod is slightly sinuate.

In the 2nd leg (Text-fig. 26, I) the exopod is composed of the usual three segments. The marginal spines on the 1st and 3rd segments are small and sub-equal, but that arising from the 2nd segment is greatly increased in size and extends as far as the base of the proximal spine on the 3rd segment; there is in this respect a close degree of similarity between this species, *E. concinna* Giesbrecht and *E. consimilis* Farran. The endopod is as usual composed of a single segment.

The 3rd and 4th legs are of the usual type.

Genus *Paraeuchæta* A. Scott.

Paraeuchæta, A. Scott, 1909, p. 69.
Pareuchæta, Sars, 1925, p. 111.

At the present time this genus includes some 35 species, of which three are known from the male only.

As Giesbrecht (1892, p. 260) has pointed out in his account of the genus *Euchæta* (*sensu lato*), the 1st maxilla is rich in specific criteria. Those species of *Paraeuchæta,* in which this appendage has been described, can be separated into several groups, according to the number of setæ that arise from the outer lobe :

Group I.—In the following species Le. 1 of the 1st maxilla of the female bears in all 9 setæ, of which 6 are stout and the 2 proximal and the distal are considerably smaller :

Paraeuchæta antarctica Giesbrecht.
P. austrina Giesbrecht.
P. exigua Wolfenden.
P. glacialis Hansen.
P. gracilis Sars (= *P. quadrata* Farran).
P. hanseni With.
P. malayensis Sewell (= *P. barbata* A. Scott).
P. norvegica Boeck.
P. similis Wolfenden.
P. weberi A. Scott.

Group II.—In the following species Le. 1 of the 1st maxilla of the female bears 7 setæ, of which the 2 proximal are usually small :

Paraeuchæta barbata Brady, Farran.
P. bradyi With.
P. californica Esterly.
P. farrani With (= *P. barbata* Sars).
P. scotti Farran.

Wolfenden (1911, p. 301) states that *Paraeuchæta scotti* possesses only 5 setæ on this lobe, but it is probable that he has overlooked the 2 small proximal setæ.

Group III.—In the following species Le. 1 of the 1st maxilla of the female bears 6 setæ :

Paraeuchæta bisinuata Sars.
P. investigatoris Sewell (= *P. californica* A. Scott, *non* Esterly).
P. robusta Wolfenden.

Group IV.—In the following species Le. 1 of the 1st maxilla of the female bears 5 setæ :

Paraeuchæta flava Giesbrecht.
P. hebes Giesbrecht.
P. rubicunda Farran.

Group I.

Paraeuchæta hanseni (With).

Euchæte hansenii, With, 1915, p. 181, text-figs. 52 *a*, *b*.
Pareuchæta hanseni, Sars, 1925, p. 115, pl. xxx, figs. 15–18.

Occurrence.—Sta. 172, Central part of Arabian Sea, 2091–0 m., 1 female.

Remarks.—The total length of this specimen was 9·8 mm., which is slightly larger than either With's original example, which measured 8·9 mm., or Sars' examples, which were 9·4 mm. With (1915, p. 182) points out that this species is nearly related to *P. sarsi* (Farran), "but is easily distinguished by the smaller size, by the structure of the genital somite, by the 9 setæ in the Le. 1 of the maxillulæ, and by the well developed Se. Re. pes 1." As regards size, this does not hold good, for while With's specimens of *P. sarsi* measured 10 mm., Sars' specimens were only 8·7 mm., and those taken by the John Murray Expedition were still smaller, measuring only 8·47 mm., which is thus considerably smaller than examples of *P. hanseni*.

The present specimen showed the typical structure of the genital aperture.

Occurrence.—Up to the present time this species has only been recorded off south-west Greenland (Jespersen), from the North Atlantic, lat. 60° N. (With), and near the Azores (Sars, Rose). The present record extends the distribution to the Arabian Sea.

It would appear to be a deep-water form, for Sars' examples were taken in hauls from 3000 and 3250 metres, and the present specimen in one from 2091 metres.

Paraeuchæta malayensis Sewell. (Text-fig. 27, a–f.)

Paraeuchæta barbata (*non Euchæta barbata* Brady), A. Scott, 1909, p. 79, pl. xviii, figs. 1–8.
Paraeuchæta malayensis, Sewell, 1929, p. 160, text-figs. 62, *a–j*.

Occurrence :

Sta. 131 D, Central part of Arabian Sea, 1500–0 m., 1 female.

Sta. 172, Central part of Arabian Sea, 850–0 m., 4 females, 1 male.

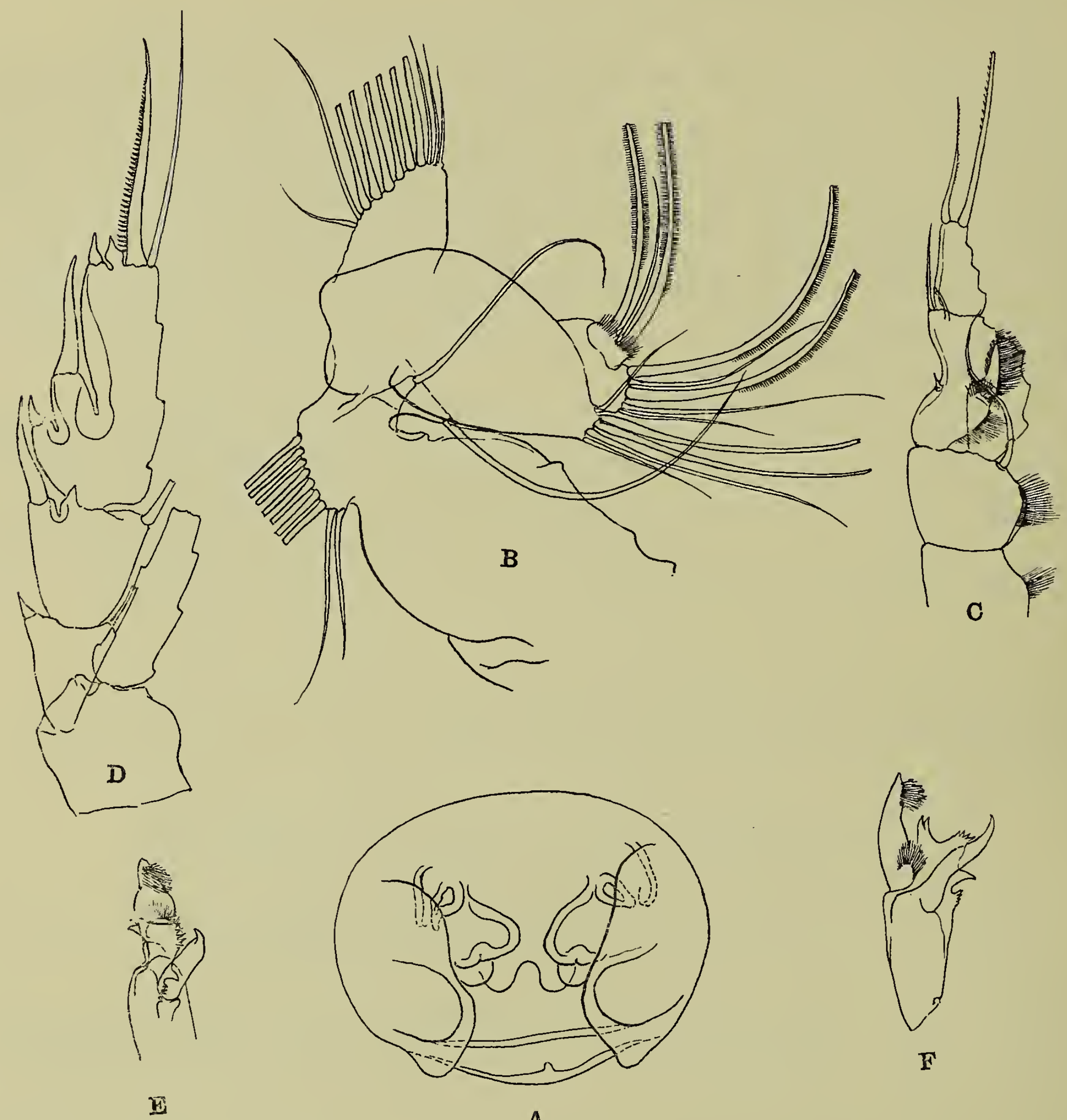
Descriptive Notes.—♀. Total length, 6·8–7·0 mm.

The proportional lengths of the cephalothorax and abdomen are as 68 to 32. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
283	146	88	93	70	128	74	65	7	46 = 1000

The rostrum is directed downwards, thus resembling the condition present in *Paraeuchæta barbata*. The posterior thoracic margin is rounded and is provided with a dense bunch of long hairs ; the postero-ventral region is slightly emarginate. In the stained specimen a narrow line of fusion can be seen between thoracic segments 4 and 5. The dorso-lateral spine on segment 5 is absent. The genital segment closely resembles that of *Paraeuchæta sarsi* Farran and allied species : on either side of the genital aperture (Text-fig. 27, a) there is a lobe that is rounded posteriorly. When viewed from the ventral aspect the genital aperture is seen to be oval in shape, and on each side is the ear-shaped swelling of the lateral lobe, between which lies a pair of smaller ear-shaped swellings ; in front of these latter are paired curved thickenings with the concavity posterior, and at the

posterior end of the aperture are a pair of widely separated, curved thickenings, with the concavity directed inwards. On the left side in the ventro-lateral region and on a line with the posterior margin of the genital aperture is a low crescentic ridge of thickened chitin, that does not, however, form a definite papilla. The ventral aspect of the 3rd,



TEXT-FIG. 27.—*Paraeuchæta malayensis* Sewell. A, Genital aperture, ♀. B, 1st maxilla, ♀. C, 1st leg, ♀. D, 2nd leg, ♀. E, Clasping organ of left 5th leg, ♂. F, Another view of same.

4th and 5th abdominal segments are furnished with long hairs, and the furcal rami are also hairy on the ventral and lateral aspects. On the dorsal part of the posterior margin of the 3rd abdominal segment is a group of two or three large spinules. The anal segment is very short and is telescoped into the 4th segment. The 1st, 3rd and 4th furcal setæ are of approximately equal length, but the 2nd seta is much longer, the proportional lengths being as 80 to 190 ; the accessory setæ measure 380.

The 1st antenna reaches back as far as the middle of the 2nd free (3rd) abdominal segment: in my previous account (Sewell, 1929, p. 161) I stated that it reached back to the posterior thoracic margin. but this appears to be incorrect. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	54	38	22	22	24	24	24	30	20	20	26	39	41	48	60	58	60	71

20.	21.	22.	23.	24–25.	
69	64	60	51	75	= 1000

The combined 24th and 25th segments are together longer than the 19th segment. The 2nd to 13th segments inclusive are provided on their posterior aspects with long hairs.

The 2nd antenna and mandible are of the usual type.

In the 1st maxilla (Text-fig. 27, B) the outer lobe bears 7 large setæ and posteriorly two other smaller ones, making 9 in all. The exopod bears 11 setæ. The inner lobe 1 bears 12 setæ; inner lobes 2 and 3 each bear a single stout seta. The 2nd basal segment bears 5 setæ, of which the inner- and outermost are very small. The 1st segment of the endopod bears 5 setæ, of which 2 are stout and are spined along one margin, and the combined 2nd and 3rd segments bear 3 setæ, of which the middle one is small and the 1st and 3rd are stout, and are spined along both margins. At the base of these setæ on endopod 2–3 is a group of fine hair-like spinules.

The 2nd maxilla and the maxilliped have the usual characters.

In the 1st leg (Text-fig. 27, C) the exopod is composed of the usual two free segments, segments 1 and 2 being fused, but the line of fusion is clearly seen on the inner part of the ramus. The outer border is markedly convex, and there is a small spine on the region that corresponds with the distal end of segment 1. The part corresponding to the 2nd segment bears a delicate whip-like outer seta, that reaches almost to the end of the terminal segment.

In the 2nd leg (Text-fig. 27, D) the marginal spine on the 2nd segment of the exopod reaches to the tip of the 1st marginal spine on the 3rd segment, and the 2nd marginal spine on the 3rd segment reaches to the middle of the 3rd spine. The sinus at the base of the 2nd spine is very deep and extends proximal to a line joining the base of the 1st marginal spine and the 2nd inner seta, thus resembling the condition present in *P. rubicunda* Farran.

Distribution.—This species has now been recorded from the Malay Archipelago (A. Scott, under the name *P. barbata*), the Bay of Bengal (Sewell), and the Arabian Sea (present record).

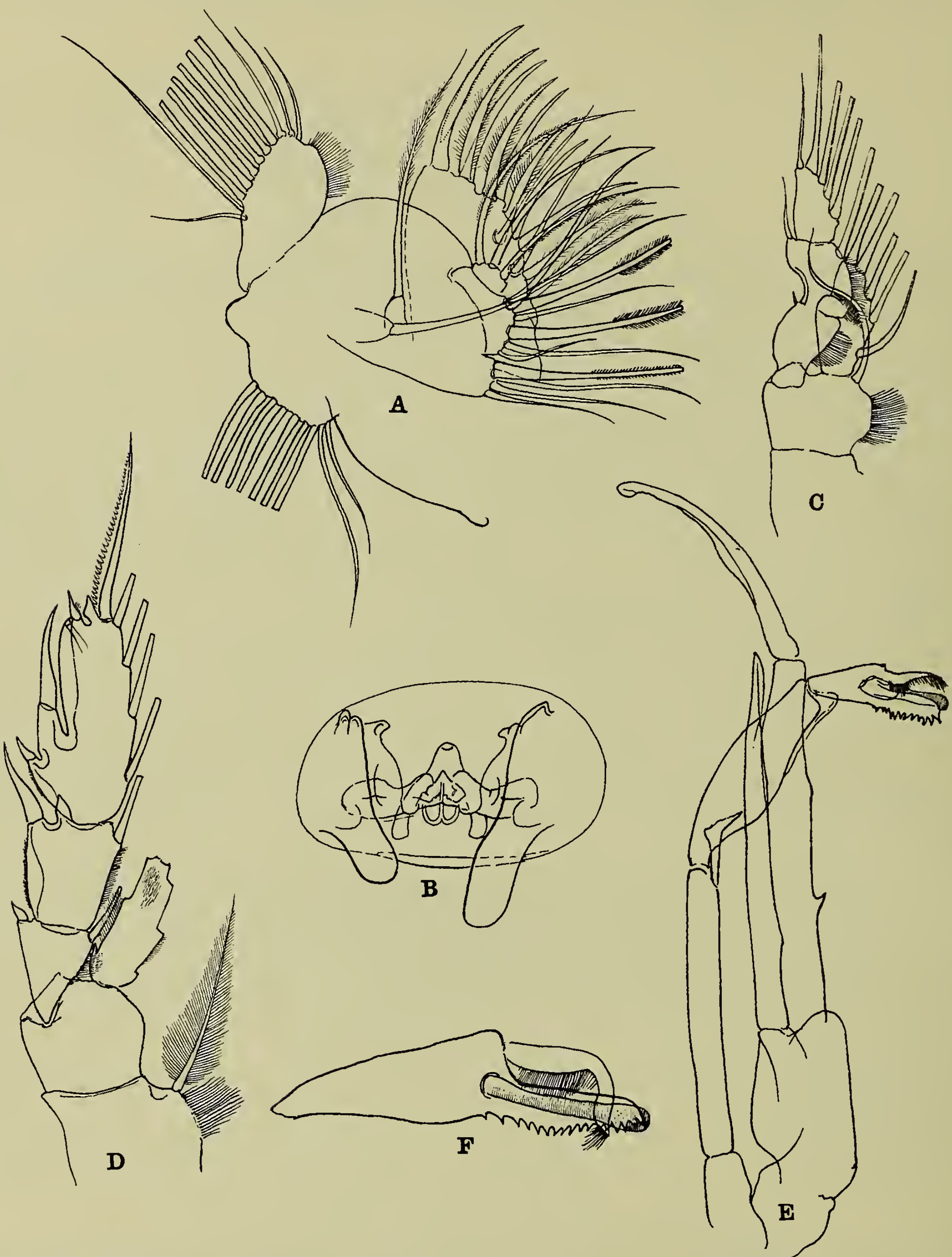
Paraeuchæta weberi A. Scott. (Text-fig. 28, A.)

Paraeuchæta weberi, A. Scott, 1909, p. 74, pl. xv, figs. 9–16; Sewell, 1929, p. 169, text-fig. 63, *a–f*.

Occurrence:

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female.
Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., vertical, 4 females.
Sta. 172, Central part of Arabian Sea, 400–0 m., 2 females; 850–0 m., 18 females.
Sta. 186, Gulf of Aden, 600–0 m., 2 females.

Remarks.—In my (Sewell, 1929, p. 170) description of the maxilla of this species I stated that the 1st inner or masticatory lobe carried 13 setæ, and that the combined 1st



Text-fig. 28.—*Paraeuchæta weberi* A. Scott. a, 1st maxilla, female. *Paraeuchæta investigatoris* Sewell. b, Genital aperture, female. c, 1st leg, female. d, 2nd leg, female. e, 5th pair of legs, male. f, Clasping organ of left 5th leg, male.

and 2nd segments of the endopod carried 7 setæ and the 3rd segment 3 ; in the present specimen, that I have dissected, the 1st inner lobe bears 12 setæ, the 2nd and 3rd lobes

1 each ; the 2nd basal segment has 4 setæ, the 1st segment of the endopod bears 6 setæ, and the combined 2nd and 3rd carries 3 ; the exopod bears 11 setæ and the outer lobe 9, of which the posterior two are smaller than the others. This species thus belongs to the 1st Group.

Distribution.—Up to the present time this species has only been recorded from the Indo-Malayan region. It has been taken in the Malay Archipelago (A. Scott), in the Laccadive Sea (Sewell), the Arabian Sea and Gulf of Aden (present records).

Group II.

Paraeuchæta scotti (Farran). (Text-fig. 28, b–f.)

Euchæte scotti, Farran, 1908, p. 42, pl. iii, figs. 11–13 ; ? Wolfenden, 1911, p. 301, pl. xxxv, fig. 2, text-figs. 53 *a–c*.
Euchæta scotti, With, 1915, p. 179, pl. vi, figs. 10 *a–c*, text-figs. 51 *a–j*.
Parauchæta scotti, Sars, 1925, p. 116, pl. xxxii, figs. 1–6.

Occurrence.—Sta. 131 D, Central part of Arabian Sea, 500–0 m., 1 female.

Remarks.—Total length, 5·0 mm. The length appears to range from 4·2 to 6·3 mm., according to the locality and perhaps the depth.

In the present specimen the posterior thoracic margin bears a small blunt prominence. The proportional lengths of the abdominal segments are as 39, 23, 22, 5, 12. The genital prominence when viewed from the ventral aspect closely resembles the figure given by Sars (1925, pl. xxxii, fig. 4).

Distribution.—This species has now been taken off the west of Greenland, from Davis Strait to Baffin Bay (Jespersen), in the North Atlantic from lat. 62° 47′ N. (With) and lat. 54° 51′ N. (Lysholm and Nordgaard), off the west coast of Ireland (Farran), near the Azores (Sars) and in the Equatorial region (Wolfenden). The present record extends its distribution to the Arabian Sea.

Group III.

Paraeuchæta bisinuata Sars.

Euchæta bisinuata, Farran, 1908, p. 45, pl. iii, figs. 17–19, pl. iv, fig. 4 ; A. Scott, 1909, p. 70, pl. xvi, figs. 10–17 ; With, 1915, p. 183, text-fig. 54 *a–j*, pl. vi, fig. 11 *a–e* ; Sars, 1925, p. 123, pl. xxxiii, figs. 16–22.

Occurrence.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

Distribution.—In the Malay Archipelago (A. Scott). In the Indian Ocean in the Bay of Bengal and Laccadive Sea (Sewell), and the northern area of the Arabian Sea (present record). In the Atlantic Ocean off the Azores (Rose), from the Azores and Canary Islands, on the coast of Portugal and in the Gulf of Gascony (Sars), off the west coast of Ireland (Farran), as far north as lat. 61° 30′ N. (With), and off Greenland (Jespersen).

Paraeuchæta investigatoris Sewell.

Paraeuchæta investigatoris, Sewell, 1929, p. 158, text-figs. 60, *a–d* (♂).
Paraeuchæta californica (*non* Esterly), A. Scott, 1909, p. 71, pl. xv, figs. 1–8 ; Sewell, 1929, p. 158 (♀).

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 16 females, 4 males.

Sta. 172, Central part of Arabian Sea, 400–0 m., 2 females, 9 males ; 850–0 m., 36 females, 9 males.

Sta. 186, Gulf of Aden, 575–0 m., 6 females, 1 male ; 600–0 m., 61 females, 14 males.

Descriptive Notes.—This species was recorded by A. Scott (*loc. cit.*) from the Malay Archipelago under the name *P. californica* (Esterly) ; he obtained females only. The male was described by me from specimens taken in the Bay of Bengal, and to these I gave the name *P. investigatoris*. A study of the examples taken in the present collection has convinced me that the form with which A. Scott was dealing was not identical with that described from the San Diego region by Esterly as *P. californica*. I am also of the opinion that these two forms represent the two sexes of the same species, and therefore the name given to the male must apply also to the female.

♀. Total length, 6·58–7 mm. This is considerably smaller than *P. californica* Esterly, which measured 8 mm. in length. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
305	126	101	81	68	127	76	68	10	38 = 1000

The supra-rostral eminence is low and the rostrum projects markedly forwards. The cephalon is only incompletely fused with the 1st thoracic segment, and the chitin easily splits along the line of fusion. The postero-lateral region of the fused 4th and 5th thoracic segments is produced backwards in a rounded margin, that bears on its inner aspect a somewhat scanty tuft of long hairs. The genital segment is clearly different from that of *P. californica* Esterly, as A. Scott has himself pointed out. The two wings on either side of the genital aperture are much more pronounced in the present species, and are unequal in size, that on the left side projecting further backwards than that on the right : both laminæ project considerably beyond the posterior margin of the genital aperture. Esterly (1906, pl. x, fig. 30) gives a somewhat rough illustration of the ventral view of the genital aperture, and a comparison of this with Text-fig. 28, B reveals that there is not the slightest resemblance between the two forms. Abdominal segments 3 and 4 (the 2nd and 3rd free segments) are armed with scattered small spinules on the dorsal aspect and bear a fringe of long hairs ventrally. Abdominal segment 4 is armed with 4 blunt spines on the dorsal part of the posterior margin. The anal segment bears some long hairs ventrally, and the furcal rami are fringed with long hairs on the lateral and ventral aspects. The 2nd furcal seta is considerably longer than the others, and the proportional lengths of the various setæ are as follows :

Average length of 1st, 3rd and 4th setæ	80
Length of 2nd furcal seta	175
Length of accessory seta	280+

Unfortunately in no case was the accessory seta complete.

The 1st antenna reaches back to about the posterior end of the cephalothorax. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	56	40	22	21	24	25	26	36	22	23	31	40	42	50	55	53	54	61

20.	21.	22.	23.	24–25.	
65	61	60	62	71	= 1000

The combined 24th and 25th segments are together considerably longer than the 19th segment. The 2nd to 13th segments inclusive bear a row of hairs on their posterior borders.

In the 2nd antenna the 1st basal segment bears a row of long hairs on its inner margin, and an external seta.

The mandible is of the usual type.

In the 1st maxilla the number of setæ arising from the parts of the appendage are as follows:

The 1st inner lobe	13
The 2nd inner lobe	1
The 3rd inner lobe	1
Basal 2	4
Endopod 1	6
Endopod 2–3	3
Exopod	11
Outer lobe	6

In the number of setæ arising from the outer lobe, this species differs from *P. californica* (Esterly), in which there are 7.

♂. The male of this species was described by me (Sewell, 1929, p. 158) from the Bay of Bengal. In the general character of the 5th pair of legs this species closely resembles the males of *P. antarctica* (Giesbrecht) and *P. russelli* (Farran), so far as the shape and armature of the comb-like ridge of the 2nd joint of the exopod of the left leg is concerned. In my original account of this appendage I stated that there was "a line of five teeth on the inner border," but I have been unable to detect these in the present specimens.

Distribution.—This species has now been taken in the Malay Archipelago (A. Scott, as *P. californica*), the Bay of Bengal (Sewell), the Arabian Sea and the Gulf of Aden (present records).

Paraeuchæta sarsi Farran. (Text-fig. 29, a, b.)

Paraeuchæta sarsi, Farran, 1908, p. 41, pl. iii, figs. 15, 16; Sars, 1925, p. 114, pl. xxxi, figs. 8–14.
Euchæta sarsi, With, 1915, p. 177, pl. vi, figs. 7, *a*, *b*, text-figs. 50, *a–f* (♀ only).
non Paraeuchæta sarsi, A. Scott, ♂, 1909, p. 75, pl. xxi, figs. 9–15.

Occurrence:

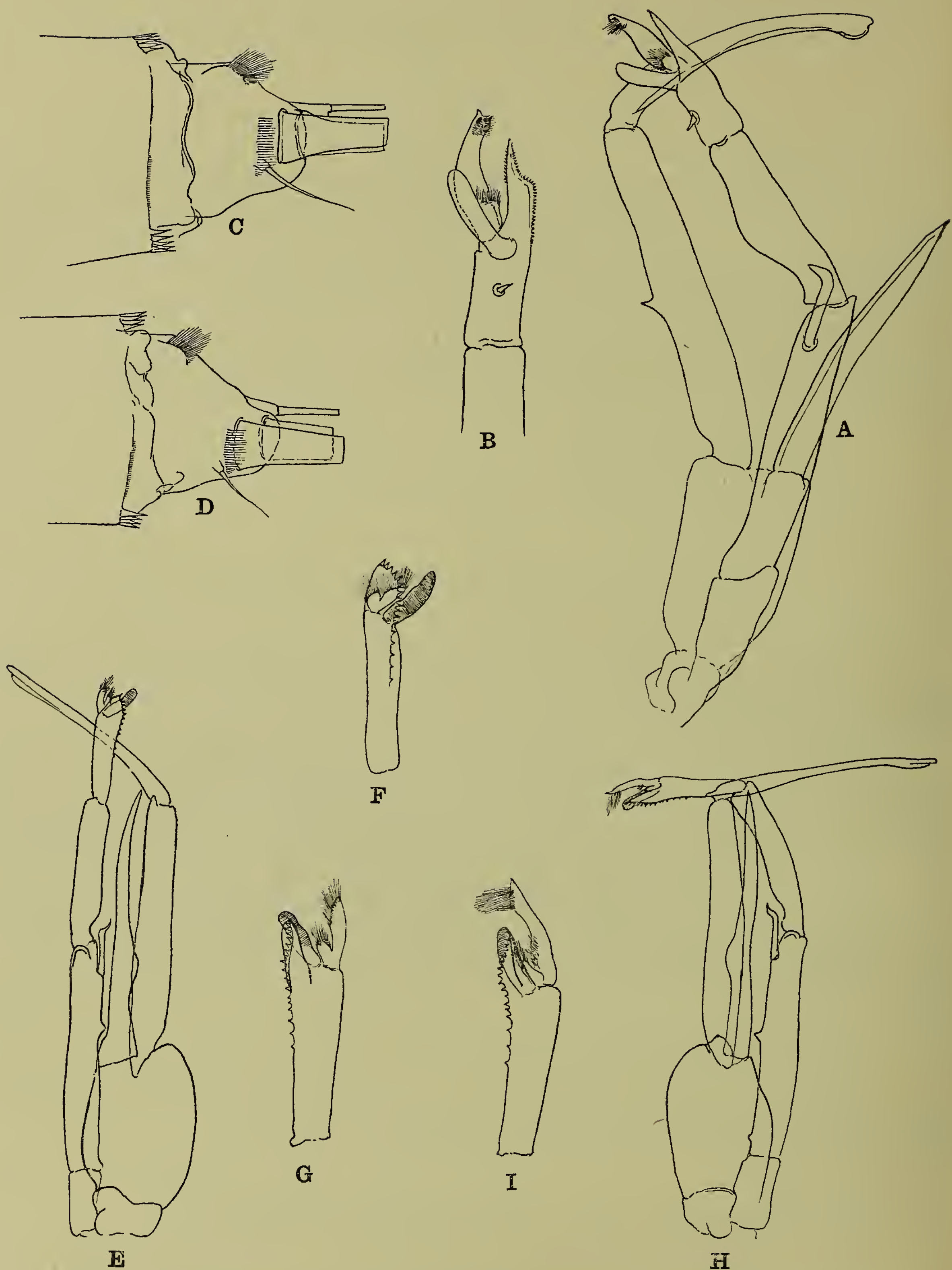
Sta. 131 A, Southern area of Arabian Sea, 600–0 m., 1 female.

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female; 2500–0 m., 1 female.

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female, 1 male.

Remarks.—♀. Total length, 8·47 mm.

The proportional lengths of the cephalothorax and abdomen are as 66 to 40. The



TEXT-FIG. 29.—*Paraeuchœta sarsi* Farran. A, 5th pair of legs, male. B, Clasping organ of left 5th leg, male. *Paraeuchœta spinifera* Esterly. C, Anal segment. *Paraeuchœta tonsa* Giesbrecht. D, Anal segment. *Paraeuchœta spinifera* Esterly. E, 5th pair of legs, male. F, Clasping organ of left 5th leg, male. G, Another view of same. *Paraeuchœta tonsa* Giesbrecht. H, 5th pair of legs, male. I, Clasping organ of left 5th leg, male.

proportional lengths of the various segments of the body, measured in the mid-dorsal line, are as follows :

Cephalon. Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1-2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
415	84	84	78	133	76	71	12	47 = 1000

The rostrum is directed forwards. The posterior thoracic margin is somewhat acutely rounded. The genital segment shows no trace of any lateral tubercle. The proportional lengths of the 3rd and 4th furcal setæ, the 2nd furcal seta and the accessory seta are as 1 : 2·5 : 8·3.

♂. The single specimen of the male was slightly damaged, but the 5th pair of legs were intact (Text-fig. 29, A). These agree closely with the description and figures given by Sars (1925, pl. xxxi, figs. 13, 14), but differ from the accounts given by A. Scott (1909, pl. xxi, fig. 15) ; the spinous process of the terminal segment of the left leg (Text-fig. 29, B) is sharply constricted at about two-thirds of its length and then tapers to a sharp point, whereas in Scott's figure this process is shown as bluntly rounded ; the middle smooth, bluntly rounded process in the present specimen is distinctly, though slightly, shorter than the spinous process, whereas With shows it as considerably longer in the specimens that he took to be the male of this species. The male described by A. Scott (1909) appears to me to correspond to the form described by Sars (1925, pl. xxxi, figs. 5–7) as the male of *P. barbata* Brady, and earlier by With (1915, pl. vi, fig. 8 *b*) under the same name.

Distribution.—The species has now been taken in the Malay Archipelago (A. Scott), the Arabian Sea (present records), the North Atlantic (Sars), off the coast of Ireland (Farran), as far north as 61° 30′ N. (With), and South of Davis Strait (Jespersen).

? *Paraeuchæta spinifera* Esterly. (Text-fig. 29, C, E, F and G.)

Euchæta spinifera, Esterly, 1906, p. 62, pl. ix, fig. 8, pl. xi, fig. 35, pl. xiv, figs. 82, 83.
Paraeuchæta spinifera, A. Scott, 1909, p. 75, pl. xxii, figs. 9–16.

Occurrence.—Sta. 172, Central area of Arabian Sea, 850–0 m., 1 male.

Descriptive Notes.—♂. This single specimen exhibits a close resemblance to the form very briefly described and inadequately figured by Esterly from the San Diego region of the coast of California.

♂. Total length, 6·28 mm.

Esterly's original example measured 5·1 mm. A. Scott (1909) obtained in the "Siboga" collection a single specimen that he doubtfully referred to this species, and that measured 5·5 mm. If A. Scott and I are correct in referring our examples to Esterly's species, it would appear that there is a progressive increase in size as we pass from east to west.

The proportional lengths of the various segments of the body are as follows, and for the purpose of comparison I have given the corresponding measurements in *Paraeuchæta tonsa* :

	Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
spinifera	407	82	82	75	66	91	101	59	13	24 = 1000
tonsa	392	85	79	78	69	93	101	66	13	24 = 1000

Esterly states that in the abdomen of *spinifera* "the genital and anal segments (are) equal in length, the second longer than any other and nearly as long as the last two." This description is clearly inaccurate and misleading, for in all the Euchætidæ the anal segment is remarkably short and is telescoped into the 4th segment. Presumably what Esterly meant is that the genital segment and the 4th abdominal segment are equal, and the second segment is equal to the 3rd and 4th together. In the present specimen the first holds good, but the 2nd segment is actually shorter than the 3rd and very much shorter than the 3rd and 4th together. It is clear that there is little or no difference between the present specimen and *Paraeuchæta tonsa* in the proportions of the body, and the same is true of many other characters.

Esterly has described the presence on the posterior margin of the thorax in the dorso-lateral region of a short spine, and it is, presumably, this character that is referred to in the specific name, *spinifera ;* an exactly similar spine is present in the males of *Para-euchæta tonsa*, *P. investigatoris* and *P. malayensis.*

In both *tonsa* and *spinifera* the posterior thoracic margin is very slightly more produced, and is more sharply rounded on the left side than on the right ; in both forms there is an absence of any tuft of hair on the margin. The proportions of the abdominal segments are almost identical, such slight differences as are indicated above being within the limits of individual variation. In both forms the 2nd, 3rd and 4th segments are fringed on their dorsal and ventral aspects with triangular spinules, but the lateral aspects are smooth, except in the 4th segment, where in each form there is a row of minute spinules. In both the 2nd furcal setæ are about twice the length of the others, and the accessory seta is about $1\frac{1}{2}$ times the length.

The 1st antenna consists of the usual 21 joints, segments 8–10 and 12–13 being fused, as well as the 24 and 25 segments. The proportional lengths of the various segments in these two species are as follows :

Segment.	1.	2.	3.	4.	5.	6.	7.	8–10.	11.	12–13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24–25.	
spinifera	51	41	19	20	24	27	32	67	21	67	37	45	54	57	59	72	71	60	58	51	66	= 1000
tonsa	51	41	19	20	24	27	32	68	22	67	37	43	53	55	59	72	71	62	59	52	66	= 1000

The 2nd antenna and mouth parts appear to be identical in this form and in *P. tonsa.*

The swimming legs also appear to be identical.

In the 5th pair of legs (Text-fig. 29, E–G) the sole difference appears to lie in the clasping "hand" of the terminal segment of the left exopod. In *spinifera* the dentate lamella is not so acutely pointed as in *tonsa* ; the "dactylus" is considerably shorter than in *tonsa.*

If I am right in thinking that this specimen is a representative of the form *P. spinifera* Esterly, it would appear to be extremely doubtful whether this species can justifiably be separated from *P. tonsa*, and I am inclined to regard Esterly's form as a local variation characteristic of the Pacific Ocean but extending as far as the Indian Ocean, and the form described by With as the male of *P. tonsa* as the Indo-Atlantic form.

Distribution.—This form has now been recorded from the San Diego region of the

Californian coast, where it was taken in a haul with several examples of *Paraeuchæta tonsa* (Esterly) ♀, from the Malay Archipelago (A. Scott) and from the Arabian Sea (present record).

Paraeuchæta tonsa Giesbrecht. (Text-fig. 29, D, H and I.)

Euchæta tonsa, Giesbrecht, 1895, p. 251, pl. iv, figs. 9, 10; Esterly, 1906, p. 64, pl. ix, fig. 10, pl. x, fig. 32; With, 1915, p. 166, pl. vi, figs. 4 *a*, *b*, text-figs. 46 *a–g*.
Paraeuchæta tonsa, A. Scott, 1909, p. 72, pl. xiv, figs. 8–15; Sars, 1925, p. 122, pl. xxxiii, figs. 9–15.

OCCURRENCE:

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 male.
Sta. 131 D, Central part of Arabian Sea, 1500–0 m., 1 male.
Sta. 172, Central part of Arabian Sea, 850–0 m., 1 male.

REMARKS.—♂. Total length, 6·167 mm.

This is slightly larger than the specimens taken by the "Thor" Expedition in the North Atlantic Ocean, which measured 5·89 mm.

The structure of the grasping "hand" of the exopod of the 5th left leg (Text-fig. 29, H, I) agrees closely with the figure given by Sars (1925, pl. xxxiii, figs. 13–15).

DISTRIBUTION.—In the Pacific Ocean, in the San Diego region of the Californian coast (Esterly), in the east Pacific region (Giesbrecht), and in the Malay Archipelago (A. Scott). In the Indian Ocean in the Arabian Sea (present records) and beneath the Agulhas Current (Cleve). In the South Atlantic Ocean (Wolfenden), in the North Atlantic Ocean (Wolfenden, Sars, Rose), off the west coast of Ireland (Farran), and to the south and west of Iceland (With).

Paraeuchæta withi sp. nov. (Text-fig. 30, A–C.)

Euchæta sarsi (♂), With, 1915, p. 178, pl. vi, fig. 7*b*.

OCCURRENCE.—Sta. 131 D, Central part of Arabian Sea, 1500–0 m., 1 male.

DESCRIPTIVE NOTES.—♂. This single specimen clearly agrees with the form that With attributed to *Paraeuchæta sarsi* Farran. In his account of this species With remarks, "that the described females are identical with *E. sarsi* Farran, I regard as quite evident; in contrast to Farran I do not regard it as identical with Wolfenden's *E. barbata*. The described male is certainly different from that which has been referred to *E. barbata*, and belongs certainly to *E. sarsi* or another species of similar size nearly related to it. I do not think that the male, which A. Scott refers to *E. sarsi*, is identical with the described one, on account of the well-developed lateral dorsal teeth of the fifth thoracic tergite and the different shape of the serrated process."

The total length of the present specimen is 8·40 mm.; With gives the length of his example as 8·3 mm.

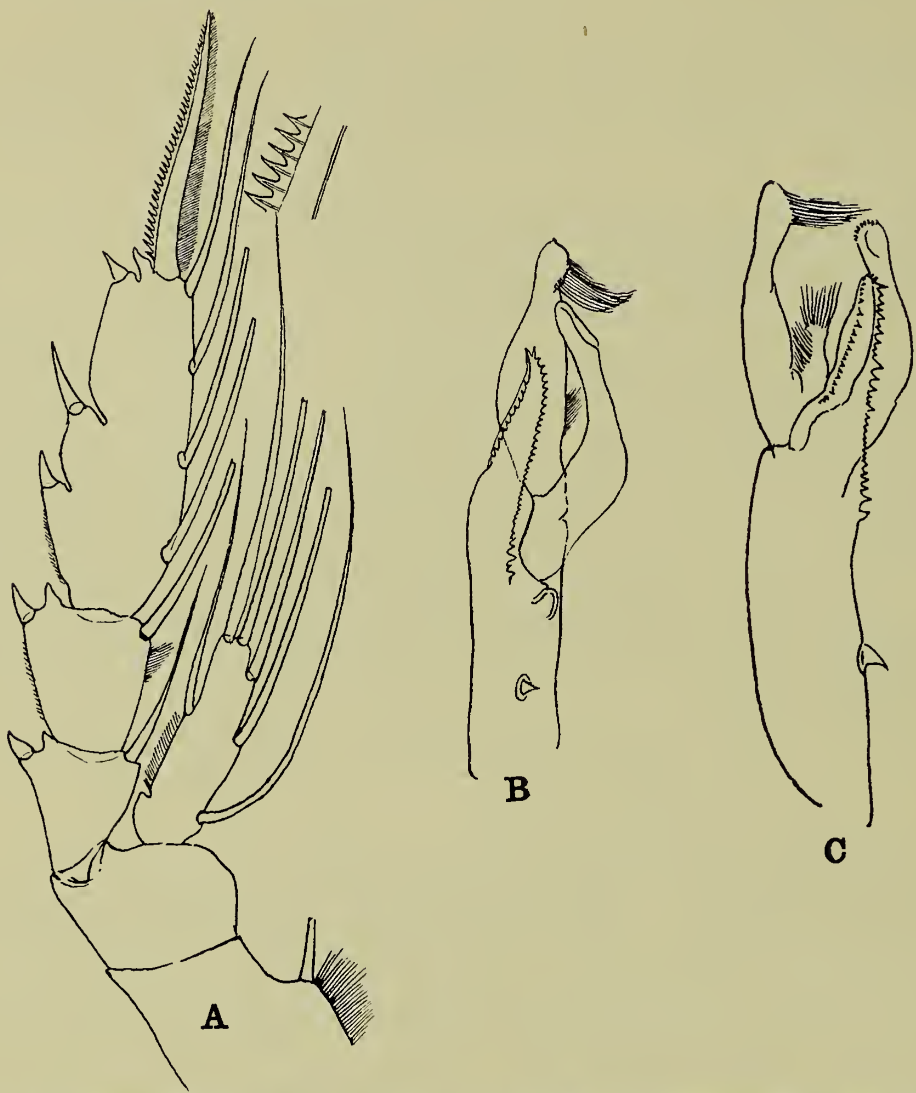
The proportional lengths of the anterior and posterior regions of the body are as 67 to 33.

As in With's specimens, the rostrum is directed forwards and the dorso-lateral tooth of the 5th thoracic segment is poorly developed. The posterior thoracic margin is produced somewhat backwards into a slight wing.

In the 1st swimming leg the marginal spine on the 1st segment of the exopod is completely absent.

A comparison of Text-fig. 30, B, C, with that given by With (1915, pl. vi, fig. 7*b*) clearly indicates the identity of the two examples.

Distribution.—This form has now been recorded from the north Atlantic Ocean (With) and the Arabian Sea (present record).



Text-fig. 30.—*Paraeuchæta withi* sp. nov., male. A, 2nd leg. B, Clasping organ of left 5th leg. C, Another view of same.

Family Phænnidæ.

Genus *Xanthocalanus* Giesbrecht.

Xanthocalanus, Giesbrecht, 1892, p. 286.

Xanthocalanus greeni Farran. (Text-fig. 31, A–F.)

Xanthocalanus greeni, Farran, 1905, p. 39, pl. viii, figs. 1–13 ; Sars, 1925, p. 132, pl. xxxvi, figs. 1–18.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 male.

Remarks.—♂. Total length, 7·1 mm.

TEXT-FIG. 31.—*Xanthocalanus greeni* Farran, male. A, Anal segment and furcal rami. B, 1st maxilla. C, 2nd maxilla. D, 1st leg. E, 2nd leg. F, 5th pair of legs.

This is somewhat larger than the example described by Sars, which measured 6·5 mm. With (1915, p. 235) has described what he took to be a male of this species in the Vth Copepodid stage, which measured as much as 8·12 mm. in length.

The present specimen agrees extremely closely with the description and figures given by Sars (*loc. cit.*). The forehead is arched, but shows no trace of a crest. The rostrum forms a wide prominence that terminates in a pair of long slender spines. The line of demarcation between thoracic segments 4 and 5 is clearly visible, and the posterior thoracic margin is produced backwards beyond the posterior border of the 1st abdominal segment in a broad wing, that has a small angular prominence in the dorso-lateral region. The proportional lengths of the various segments of the body, measured in the mid-dorsal line, are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
438	101	79	67	45	46	63	52	49	11	49 = 1000

Both the anal segment and the furcal rami are hairy on their ventral aspects (Text-fig. 31, A). Most of the furcal setæ have undergone dichotomous branching.

Both the 1st antennæ are broken off about the middle of their length, but the proximal segments are somewhat swollen and are provided with " æsthetascs."

In the 2nd antenna the 1st basal segment is provided with a fringe of long hairs internally. The exopod is slightly longer than the endopod.

The 1st maxilla (Text-fig. 31, B) agrees exactly with the figure given by Sars. The number of setæ on the various parts are as follows :

Li. 1 is expanded and bears 11 or 12 fleshy setæ.

Li. 2 in the stained specimen appears to be composed of two segments, of which the proximal bears a single seta and the distal two setæ.

Li. 3 bears 3 setæ.

Basal II bears 4 setæ and is fringed along its inner margin with hairs.

The endopod is fused into a single segment and bears 3, 3, and 3 setæ.

The exopod bears 10 setæ.

Le. bears 7 large setæ and posteriorly 2 other smaller ones.

The 2nd maxilla (Text-fig. 31, C) agrees closely with Sars' figure and description.

The swimming legs also agree closely with Sars' description and figures.

The 5th pair of legs (Text-fig. 31, F) is identical with Sars' account. The right leg is very small, and does not extend as far as the distal margin of the 1st basal segment of the left leg : it consists of the usual number of segments ; basal 2 bears a small seta-like endopod ; exopod 1 bears a single marginal seta, and exopod 3 terminates in 2 unequal setæ. In the left leg the 2nd basal segment bears a spine-like endopod, and the 3rd segment of the exopod is somewhat pyriform and hairy. This appendage is entirely different from the account given by Wilson (1932, p. 69, fig. *b*) of the appendage in what he took to be the male of this species. It seems obvious that he was dealing with a male of an entirely different species.

Occurrence.—This species has previously been recorded from the Atlantic Ocean south of Iceland (With), off the west coast of Ireland in depths of 680–1150 fathoms (Farran), and in the Bay of Biscay (Wolfenden). The present record extends the distribution to the Arabian Sea.

Genus *Onchocalanus* Sars.

Onchocalanus, Sars, 1905*a*, p. 19.

Onchocalanus affinis With. (Text-figs. 32, A–G, 33, A–E.)

Xanthocalanus magnus, Wolfenden, 1908, p. 37, pl. vii, figs. 1–9.
Onchocalanus hirtipes, A. Scott, 1909, p. 83, pl. xxxiv, figs. 9–17 (*non* Sars).
Onchocalanus magnus, Wolfenden, 1911, p. 275, pl. xxxi, figs. 3–5.
Onchocalanus affinis, With, 1915, p. 233, text-figs. 75, *a–e*, and 76, *a–d*; Sars, 1925, p. 150, pl. xli, figs. 12–18.

Occurrence:

Sta. 76, Gulf of Oman, 1500–0 m., 1 juv. (Stage IV).

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female and 1 male, juv. (Stage V).

Descriptive Notes.—♀. Total length, 5·133 mm.

The proportional lengths of the various segments of the body, measured in the mid-dorsal line, are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
325	149	115	93	62	118	62	43	7	26 = 1000

The forehead is not produced forwards and is evenly rounded: there is no trace of any crest. The rostrum is a pair of strong spines directed downwards and somewhat backwards. The line of demarcation between the cephalon and the 1st thoracic segment is clearly visible dorsally, though it is incomplete laterally; the line of demarcation between the 4th and 5th thoracic segments is also clearly visible. The posterior thoracic margin is produced backwards into a bluntly rounded wing without a terminal spine, though there is a very small trace of a backward projection. The 1st abdominal segment is expanded opposite the genital orifice, and from thence backwards is of the same uniform diameter. There are some small short hairs around the genital orifice. The ventral aspect of segment 4 is hairy, and there are some spinules on the dorsal aspect of the furcal rami.

The 1st antenna reaches back to beyond the posterior margin of the genital segment. The proportional lengths of the segments are as follows:

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
63	38	26	26	27	27	27	37	22	26	26	43	47	59	60	60	54	53

20.	21.	22.	23.	24.	25.
52	45	45	55	60	22 = 1000

The seta on segment 24 is inserted at the junction of the middle and distal thirds of the joint.

In the 2nd antenna the two rami are of nearly equal length. The exopod consists of six segments, of which the 1st is produced in a rounded eminence.

In the mandible the biting ramus is long and somewhat weak; the teeth are small and the posterior ones are crenulate. The 2nd basal segment bears 3 setæ. Endopod 1

bears 2 setæ and the terminal segment carries 9. The exopod bears 1, 1, 1, 1, and 4 setæ on the several segments.

TEXT-FIG. 32.—*Onchocalanus affinis* With, ♀. A, 2nd maxilla. B, Maxilliped. C, 1st leg. D, 2nd leg. E, 4th leg, right. F, 4th leg, left. G, 5th leg.

In the 1st maxilla the various lobes bear the following spines and setæ :

Inner lobe I . .	9 ?, the spines are longer than the lobe itself.
Inner lobe II .	?
Inner lobe III .	4

Basal II	5
Endopod I	3
Endopod II	3
Endopod III	4
Exopod	10
Outer lobe	9

In the 2nd maxilla (Text-fig. 32, A) two of the sensory appendages, arising from the terminal part of the appendage are markedly stouter than the others.

The lengths of the various parts of the maxilliped (Text-fig. 32, B) are in the following proportions :

1st basal segment	36
2nd basal segment	42
Endopod	22

With (*loc. cit.*, p. 234) gives the lengths in his specimen as 85, 100 and 57, which reduced to the same proportional lengths corresponds to 35, 41 and 24 ; there is thus but little difference between the two examples. The sensory appendage arising from the 1st basal segment is larger than in most other species, and appears to arise nearer the proximal end of the segment.

In the 1st leg (Text-fig. 32, C) the exopod is composed of 3 segments, each bearing a well-developed marginal spine ; the 2nd segment has a group of 7 spines and the 3rd segment bears three groups of 3, 6 and 5 spines respectively ; With states that there were 3, 6 and 6 spines in these groups in his example.

Remarks.—A comparison of the description and figures given above with those of With and Sars indicates that we were all three dealing with the same species. There is also in my mind no doubt that the form described by A. Scott from the Malay Archipelago under the name *O. hirtipes* belongs to this species and not to that of Sars. It further appears to be probable that the examples taken by the "Terra Nova" in the Antarctic and described by Wolfenden under the name *Xanthocalanus magnus* belong to this species and not to the true *O. magnus* Wolfenden ; this latter species, which he described from the region off the west coast of Ireland, is much larger, and according to Sars is synonymous with *O. trigoniceps* Sars.

Accompanying this adult female were examples in Copepodid Stages V and IV.

Stage V. Total length, 4·50 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 to 24.

The proportional lengths of the various segments of the body are given below. The forehead is rounded, as in the adult. The posterior thoracic margin is produced backwards in a wing, the distal part of which narrows to a bluntly rounded eminence that is slightly curved downwards, but does not exhibit a spinous projection. The abdomen is composed of only four segments, segments 4 and 5 not yet being demarcated.

The 1st antenna reaches back to about the middle of the abdomen ; it consists of 24 free segments that have the following proportional lengths :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	72	39	25	25	27	27	27	37	23	25	27	42	46	46	58	56	53	52

20.	21.	22.	23.	24.	25.	
53	48	46	58	63	25	= 1000

The 2nd antenna and mouth-parts appear to be similar to those of the adult. In the 2nd maxilla (Text-fig. 33, A) the sensory setæ on the terminal portion are already fully developed.

The maxilliped (Text-fig. 33, B) closely resembles that of the adult.

TEXT-FIG. 33.—*Onchocalanus affinis* With, ♂, juv. A, 2nd maxilla. B, Maxilliped. C, 1st leg. D, 2nd leg. E, 5th pair of legs.

The swimming legs (Text-fig. 33, C, D) are fully developed and resemble those of the adult.

The 5th pair of legs (Text-fig. 33, E) differ from those of the adult in that the terminal segment is partially subdivided into two on each side, thus resembling the immature form of *O. trigoniceps*.

Stage IV. Total length, 3·50 mm.

The proportional lengths of the various segments of the body are given below.

The sensory setæ on the 2nd maxilla and the maxilliped are already fully developed, and as in the adult, two are much stouter than the others.

The 5th pair of legs is composed of three segments. as in the adult.

It is interesting to compare the changes in the proportional lengths of the various segments of the body in these three successive stages of development :

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca
Stage IV	371	148	93	86	51	28	56	70	70			27
Stage V	342	144	101	86	54	32	58	68	54	36		25
Stage VI	324	145	108	90	56	31	111		62	40	9	25

These measurements strongly suggest that there is a comparative reduction in the length of the cephalon at each successive moult, whereas in the 2nd–5th thoracic segments the opposite is taking place, the segment tending to increase in length at each successive ecdysis. In the abdomen such changes as are taking place in the relative lengths of the segments are somewhat obscured by the simultaneous changes in the segmentation ; but whereas the 1st and 2nd segments present but little difference, the 3rd–5th segments greatly increase in length, the sum of the lengths of these segments increasing from 70 in Stage IV, to 90 (54 + 36) in Stage V and 111 (62 + 40 + 9) in Stage VI ; during the same moults there seems to be a very slight shortening of the furcal rami.

Distribution.—The North Atlantic Ocean, lat. 61° 30′ N. (With) and off the Azores (Sars). From the Antarctic Seas (Wolfenden, as *Xanthocalanus magnus* and *Onchocalanus magnus*). From the Arabian Sea (present record) and the Malay Archipelago (A. Scott), as *Onchocalanus hirtipes*).

Onchocalanus trigoniceps Sars. (Text-fig. 34, A–G.)

Onchocalanus trigoniceps, Sars, 1905*a*, p. 20 ; 1925, p. 144, pl. xl, figs. 1–17 ; Sewell, 1929, p. 176.
Xanthocalanus magnus, Wolfenden, 1906, p. 32, pl. x.
Onchocalanus frigidus, Wolfenden, 1911, p. 276.
Onchocalanus magnus, With, 1915, p. 225, pl. vii, figs. *a–g*, pl. viii, figs. 16 *a–d*.

Occurrence :

Sta. 96, Central part of Arabian Sea. 645–400 m., 1 juv. (♂ ?).

Sta. 172. Central area of Arabian Sea, 850–0 m., 1 female. 6 juv. (♂ ?).

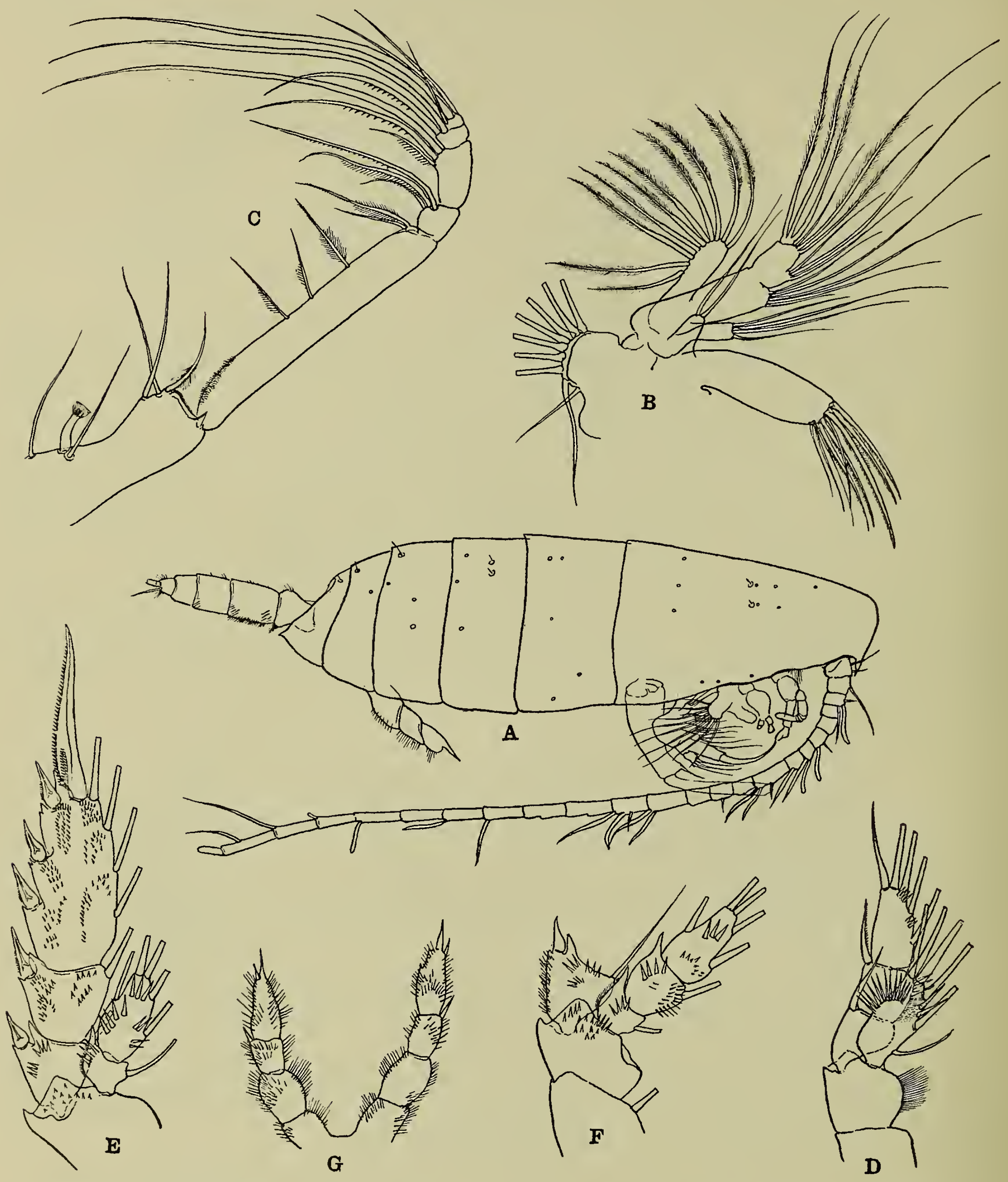
Descriptive Notes.—♀. Total length, 7·33 mm.

The proportional lengths of the cephalothorax and abdomen (Text-fig. 34, A) are as 77 to 23. Sars' examples measured 7·5 mm. and those of With 8·3 mm. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
370	148	91	82	42	20	106	69	42	7	23 = 1000

The cephalon and 1st thoracic segments are partly fused, the line of separation being visible dorsally ; the 4th and 5th thoracic segments are separated by a line that is clearly visible. The rostrum is composed of two stout spinous processes directed vertically

downwards and slightly backwards and, in this specimen, were without any filamentous prolongation. The forehead is prominent but without any trace of a crest. The posterior



TEXT-FIG. 34.—*Onchocalanus trigoniceps* Sars. A, Female, lateral view (Stage V). B, 1st maxilla. C, Maxilliped. D, 1st leg. E, 2nd leg. F, Basal portion, 3rd leg. G, 5th pair of legs, immature male.

thoracic margins are prolonged backwards in a triangular flap, at the apex of which is a short spinous projection. A number of small pores, passing through the exoskeleton, are present on the cephalon and thoracic segments in the position shown in the figure.

The genital segment of the abdomen is produced ventrally, and on either side of the genital orifice is a flap that is sharply pointed at its anterior end. The genital orifice is surrounded by an area that is profusely covered with short hairs. The posterior segments are hairy. The furcal setæ are badly damaged, but at least two were abnormal and exhibited dichotomous branching.

Unfortunately both 1st antennæ are broken; the proportional lengths of the segments that are present are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	66	33	28	28	31	31	31	44	24	28	32	41	47	56	56	55	53	50

The appendages agree very closely with the description and figures given by Sars.

Copepodid stage V. Accompanying this female were 6 examples in the last copepodid stage.

♂. Total length, 5·77 mm.

The proportional lengths of the cephalothorax and abdomen are as 75 to 25. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
372	127	87	83	57	20	66	74	63	27	24 = 1000

The cephalothorax resembles that of the female; the forehead is prominent and the rostrum is composed of two spines, each without any terminal filament. In the abdomen the 1st and 2nd segments are separate, and the 4th and 5th are fused. The segments are covered with short hairs. In most examples the furcal setæ were broken off, but none showed any abnormal dichotomy.

The 1st antenna reaches back beyond the furcal rami. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	70	32	23	23	29	29	29	41	23	28	32	41	47	60	60	60	54	53

20.	21.	22.	23.	24.	25.
52	43	43	54	57	17 = 1000

The 2nd antenna and mouth parts agree closely with those of the adult female. In the 2nd maxilla the setæ arising from the distal part of the appendage are modified into sensory organs, as in the adult female.

The swimming legs also resemble those of the female.

The 5th legs (Text-fig. 34. G) are each composed of four segments, instead of three as in the female; they thus agree closely with the figure given by With (1915, pl. viii, fig. 17 *f*) of this appendage in a young example of *O. cristatus*, and by Esterly (1906, pl. xiii, fig. 77) of *Xanthocalanus similis*, which is a synonym of *O. cristatus*.

With regards the young forms that he examined, and which appear in their structure to correspond with the above immature specimens, to be immature females, probably on account of the presence on the 2nd maxilla of the modified setæ, that are so characteristic of the adult female: I am, however, inclined to regard them as immature males.

Distribution.—The North Atlantic in lat. 61° 30′ N. (With), to the south of Davis Strait (Jespersen), in the Bay of Biscay and off the coast of Portugal, round the Azores and in the western part of the Mediterranean Sea (Sars, Rose); in the Antarctic seas (Wolfenden); and in the Arabian Sea (present record), and the Laccadive Sea (Sewell).

Family Scolecithricidæ.

Genus *Scolecithricella* Sars.

Scolecithricella, Sars, 1903, p. 54.

Scolecithricella pearsoni Sewell.

Scolecithricella pearsoni, Sewell, 1914, p. 217, pl. xvii, figs. 6, 7, pl. xviii, figs. 1–4.

Occurrence.—Sta. 61 A, Northern area of Arabian Sea, surface.

Descriptive Notes.—Total length, 1·10 mm.

Distribution.—The Ceylon Pearl Banks (Sewell), and the northern area of the Arabian Sea (present record).

Scolecithricella tenuiserrata (Giesbrecht).

Scolecithrix tenuiserrata, Giesbrecht, 1892, p. 266, pl. xiii, figs. 13, 16, 24, 25, 39; pl. xxxvii, figs. 4, 12.

Occurrence.—Sta. 61 C, Northern part of Arabian Sea, surface, 1 female.

Distribution.—Originally described from the Mediterranean Sea (Giesbrecht, Rose), it has since been taken on the Australian Barrier Reefs (Farran) and the Arabian Sea (present record).

Genus *Scottocalanus* Sars.

Scottocalanus, Sars, 1905*b*, p. 7.

Scottocalanus dauglishi Sewell.

Scottocalanus dauglishi, Sewell, 1929, p. 189, text-figs. 68, *a–l*, and 69, *a–c*.

Occurrence:

- Sta. 96, Central part of Arabian Sea, 645–400 m., 59 females, 34 males.
- Sta. 145 C, Maldive area, 50–0 m. vertical, 1 female; 500–0 m. vertical 4, females.
- Sta. 145 D, Maldive Area, 300–0 m. vertical, 3 females, 3 males; 500–0 m. vertical, 9 females, 1 male.
- Sta. 172, Central part of Arabian Sea, 400–0 m., 76 females, 57 males.
- Sta. 186, Gulf of Aden, 575–0 m., 4 females, 5 males; 600–0 m., 56 females, 21 males.

Remarks.—This is by far the most common species in the genus in the area under investigation.

Distribution.—This species was previously known from the Bay of Bengal and Laccadive Sea (Sewell), and the present records extend its range to the Arabian Sea and the Gulf of Aden.

As regards its depth distribution, it seems clear that it is most common at a depth of some 400–600 metres, though it may be taken as high up as 50 metres depth.

Scottocalanus helenæ (Lubbock).

Undina helenæ, Lubbock, 1856, p. 25, pl. iv, fig. 4, pl. v, figs. 1–5.
Scolecithrix securifrons (♂), T. Scott, 1894, p. 47, pl. iv.
Scottocalanus helenæ, A. Scott, 1909, p. 111, pl. xxvii, figs. 1–9; Sewell, 1929, p. 183.
Scottocalanus thorii, With, 1915, p. 215, text-figs. 68–70, pl. vi, figs. 14, *a–c*, pl. viii, figs. 14, *a*, *b*.

Occurrence.—Sta. 145 D, Maldive Archipelago, 300–0 m. vertical, 1 male.

Remarks.—Considerable confusion has arisen regarding this species. In a previous paper I have pointed out that in my opinion this species is synonymous with *Scottocalanus thorii* With, which is identical with the form recorded by Farran from the Irish coast, but is different from *S. persecans* (Giesbrecht), and that Sars is in error in regarding *S. persecans* and *S. thorii* as synonyms.

Distribution.—In the Atlantic Ocean from the Iceland-Faroe Channel, the South of Iceland and Denmark Strait (With), the coast of Ireland and the Bay of Biscay (Farran), and the Gulf of Guinea (T. Scott). In the Indian Ocean from the Laccadive Sea (Sewell) and the Maldive region (present record). In the Pacific Ocean from the Malay Archipelago (A. Scott).

Scottocalanus persecans (Giesbrecht).

Scolecithrix persecans, Giesbrecht, 1895, p. 253, pl. iii, figs. 6–12; Esterly, 1905, p. 166, fig. 28 *a–e*.
Scottocalanus persecans, A. Scott, 1909, p. 105, pl. xxvii, figs. 10–18; Sars, 1925, p. 167, pl. xliv; Wilson, 1932, p. 80, fig. 55 *a–c*.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female, 1 male.

Distribution.—In the Atlantic Ocean from the Woods Hole region (Wilson), the Gulf of Maine (Bigelow), the North Atlantic (van Breemen, Sars) and the South Atlantic (Wolfenden). In the Indian Ocean from the east of Cape Colony (Cleve) and the Arabian Sea (present record). In the Pacific Ocean from the Malay Archipelago (A Scott), the North Pacific Ocean (Giesbrecht), and the San Diego region of the coast of California (Esterly).

Scottocalanus securifrons (T. Scott).

Scolecithrix securifrons (♀ only), T. Scott, 1894, p. 47, pl. iv, figs. 41, 43–47, 49–52, 54, 56, and pl. v, fig. 1.
Lophothrix securifrons, Wolfenden, 1904, p. 120, pl. ix, figs. 12–15.
Scottocalanus securifrons, A. Scott, 1909, p. 104, pl. xxv, figs. 1–9, pl. xxviii, figs. 1–9; With, 1915, p. 220, text-figs. 71–73, pl. viii, figs. 13 *a*, *b*; Sars, 1925, p. 160, pl. xlv, figs. 1–8.

Occurrence:

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 2 females, 2 males.

Sta. 172, Central part of Arabian Sea, 400–0 m., 18 females, 11 males; 850–0 m., 1 female.

Distribution.—In the Atlantic Ocean from the Faroe Channel (Wolfenden), the Faroe-Iceland Channel (With), the west coast of Ireland (Farran, who states that it is very characteristic), the Bay of Biscay (Canu), the North Atlantic (Sars, Wolfenden, Rose), the Gulf of Guinea (T. Scott), and in the South Atlantic (Wolfenden). In the Indian Ocean off the east of Cape Colony (Cleve) and in the Arabian Sea (present records). In the Pacific Ocean from the Malay Archipelago (A. Scott), and Suruga Bay, Japan (Tanaka).

Genus *Scaphocalanus* Sars.

Scaphocalanus magnus (T. Scott).

Amallophora magna, T. Scott, 1894, p. 55, pl. iv, figs. 5–9 ; Sars, 1901–03, p. 51, pl. xxxiv, xxxv.
Scolecithrix cristata, Giesbrecht, 1895, p. 252, pl. ii, figs. 6–9, pl. iii, figs. 1–5.
Scaphocalanus acrocephalus, Sars, 1900, p. 36, pls. vii–ix.
Scaphocalanus magnus, With, 1915, p. 189, pl. vii, figs. 8, *a–d*, pl. viii, figs. 6, *a–g*, text-fig. 58 *a–k*.

Occurrence :

Sta. 76, Gulf of Oman, 1500–0 m., 1 female (f. *minor*).
Sta. 96, central area of Arabian Sea, 645–400 m., 5 females and 1 male (juv.) (f. *major*).
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 2 females (f. *major*).
Sta. 172, Central area of Arabian Sea, 400–0 m., 1 female (f. *minor*) : 850–0 m., 10 females (f. *minor*).

Descriptive Notes.—The specimens taken at Stas. 96 and 131 D appear to agree exactly with the descriptions and figures of this species given by previous authors, but the specimens from Stas. 76 and 172 are markedly smaller. Wolfenden (1911, p. 262) has called attention to the fact that specimens from the southern Atlantic, and especially from the Antarctic region, are smaller than those from the North Atlantic.

forma *major*. (Text-fig. 35, a–i.)

♀. Total length, 4·967 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 to 24. The proportional lengths of the various segments of the body are given below (*vide* p. 146).

The head is somewhat bluntly rounded and is provided with a linear crest. The posterior thoracic margin is produced backwards in a wing, the apex of which is still further produced in a narrow rounded prominence, as figured by With (1915, text-fig. 58, *g*).

The proportional lengths of the segments of the 1st antenna (Text-fig. 35, a) are given below, and for convenience of reference I have also given the proportional lengths in f. *minor* :

Segment	1.	2.	3.	4.	5.	6.	7.	8–10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
f. *major*	82	84	31	28	29	28	25	69	21	25	36	37	39	48	50	50	48	48
f. *minor*	89	88	29	29	29	29	27	78	25	27	36	38	41	45	47	49	45	44

Segment	21.	22.	23.	24–25.	
f. *major*	50	50	60	62	= 1000
f. *minor*	44	47	56	58	= 1000

The 1st segment bears a transverse row of delicate spinules near the distal margin.

The proximal segments, from 3 to 14 or 15, are slightly dilated, when viewed from the side and appear to be flattened laterally ; the chitin is thickened along both anterior and posterior borders ; from segment 16 to the end the chitin appears to be thickened along lines running parallel to the margins.

Text-fig. 35.—*Scaphocalanus magnus* (T. Scott), f. *major*, ♀. a, 1st antenna. b, 2nd antenna. c, 1st maxilla. d, 2nd maxilla. e, 1st leg. f, 2nd leg. g, 3rd leg. h, 4th leg. i, 5th leg.

The 2nd antennæ (Text-fig. 35, B) and mouth parts (Text-fig. 35, C, D) agree with the descriptions and figures given by previous authors.

In the swimming legs (Text-fig. 35, E–H) 2, 3 and 4, in addition to the groups of large spinules on the posterior aspect of the several segments of the rami, there are patches of very small spinules on the anterior aspect of the limbs, and also on the 2nd basal segment in the 3rd and 4th legs.

The 5th leg (Text-fig. 35, I) agrees with the description of previous authors.

forma *minor*. (Text-fig. 36, A–H.)

♀. Total length, 3·550 mm.

The proportional lengths of the anterior and posterior regions of the body are as 76 to 24. The proportional lengths of the various segments of the body are given below. The forehead is more sharply rounded than in f. *major*. The posterior thoracic margin is produced backwards in a triangular, sharply rounded wing without any trace of the small projection at the apex.

The proportional lengths of the various segments of the 1st antenna (Text-fig. 36, A) have been given above, and differ only slightly from the corresponding lengths in f. *major*; the general characters of the appendage are identical in both forms.

The 2nd antenna (Text-fig. 36, B), mandible and 1st maxilla appear to be identical with the corresponding appendage in f. *major*.

The 2nd maxilla (Text-fig. 36, C) differs from that of f. *major* in that the posterior margin of the basal segment is produced backwards in a sharply rounded prominence. In this respect the shape of this appendage in these two forms agrees exactly with the difference that I have in a previous paper (Sewell, 1929, p. 125, text-fig. 71 *d*, and p. 197, text-fig. 72 *d*) noted in the two forms, *major* and *minor*, of *Lophothrix frontalis* Giesbrecht.

In the swimming legs (Text-fig. 36, D–G) there are again differences between the two forms in that in the present f. *minor* the groups of minute spinules on the anterior aspect of the rami of legs 2, 3 and 4 and on the 2nd basal segment of legs 3 and 4 are almost completely absent.

The 5th leg (Text-fig. 36, H) closely resembles that of f. *major*; in one specimen the outer marginal spine of the distal segment was wanting on one side.

Remarks.—There appear to be slight, but quite appreciable, differences between these two forms in both the proportions of the body segments and also in the proportional lengths of the segments of the 1st antenna.

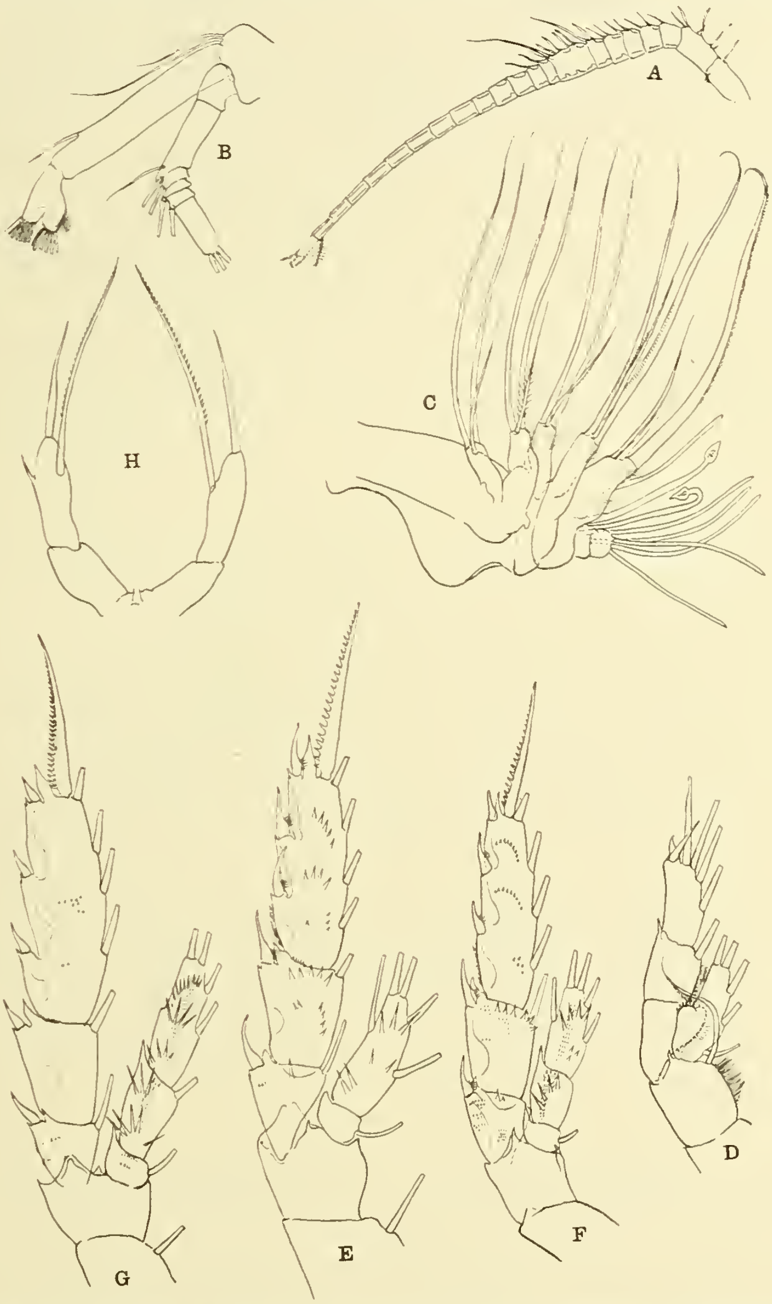
As regards the segments of the body, I give below the proportional lengths of the two forms:

	Cephalon. Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
f. *minor*	526	79	66	75	84	61	51	21	37
f. *major*	507	91	65	78	81	71	53	19	35

There thus seems to be a definite reduction in the proportional length of the fused cephalon-thoracic segment 1 as we pass from the smaller to the larger form, and this is to some extent compensated by an increase in the proportional length of thoracic segment 2. On the other hand, at the posterior end of the body there is a small reduction in the lengths of the anal segment and the furcal rami.

Distribution.—This species, in one form or another, has a world-wide distribution.

In the Arctic Ocean (Duc d'Orleans). In the Atlantic Ocean from Denmark Strait, Iceland (With), off Greenland (Damas and Koefoed), the Woods Hole region (Wilson), the Gulf of Maine (Bigelow), the coast of Norway (Sars), the west coast of Ireland (Farran), the Bay of Biscay (Farran), the North Atlantic (Sars), the Gulf of Guinea (T. Scott), the



TEXT-FIG. 36.—*Scaphocalanus magnus* (T. Scott), f. *minor*. A, 1st antenna. B, 2nd antenna. C. 2nd maxilla. D, 1st leg. E, 2nd leg. F, 3rd leg. G, 4th leg. H, 5th pair of legs.

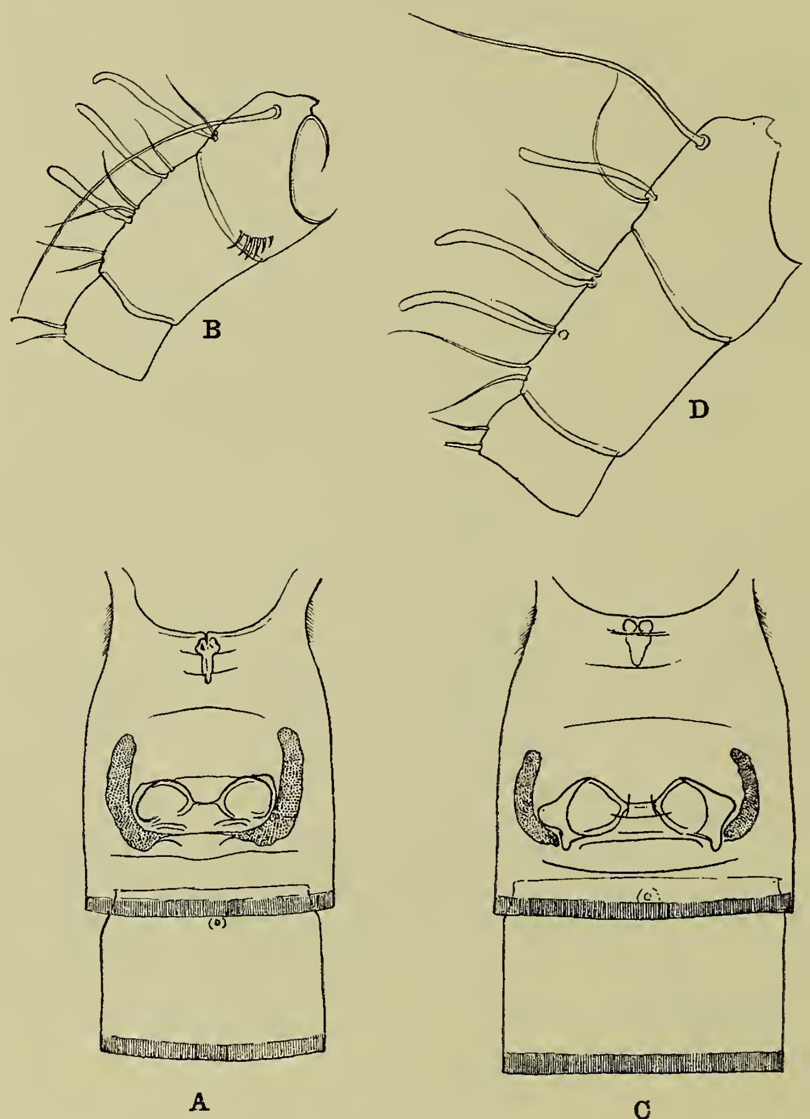
South Atlantic and the Antarctic Ocean (Wolfenden). In the Indian Ocean from the Arabian Sea and Gulf of Oman (present records), the Laccadive Sea and Bay of Bengal (Sewell). In the Pacific Ocean from the Malay Archipelago (A. Scott), the north Pacific Ocean (Giesbrecht), and the San Diego region of the coast of California (Esterly).

Genus Lophothrix Giesbrecht.

Lophothrix, Giesbrecht, 1895, p. 254.

Lophothrix frontalis Giesbrecht. (Text-figs. 37, A–D; 38, A–F.)

Lophothrix frontalis, Giesbrecht, 1895, p. 254, pl. ii, figs. 1–5 and 9–12; A. Scott, 1909, p. 99, pl. xxvi, figs. 11–20 (♀), and pl. xxix, figs. 1–10 (♂); With, 1915, p. 211, figs. 66, 67 and pl. vii, fig. 7; Sars, 1925, p. 162, pl. xlv, figs. 9–21, and pl. xlvi, figs. 1–7; Sewell, 1929, p. 193, text-figs. 70–73.



Text-fig. 37.—*Lophothrix frontalis* Giesbrecht, ♀. A, f. *minor*, genital segment, ventral view. B, f. *minor*, proximal segments of 1st antenna. C, f. *major*, genital segment, ventral view. D, f. *major*, proximal segments of 1st antenna.

Occurrence:

Sta. 96, Central part of Arabian Sea, 645–400 m., 4 females, 3 males (juv.).
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 2 females.
Sta. 145 D, Maldive area, 500–0 m., 1 female (juv.).

Sta. 172. Central part of Arabian Sea, 850–0 m., 10 females, 1 male, adult: 2 males (juv.).

Sta. 186. Gulf of Aden, 600–0 m., 2 females.

Remarks.—I have in a previous paper (Sewell, 1929) called attention to the occurrence in this species of two size groups. Examples of both groups were obtained in the present collection.

f. *minor*.

♀. The majority of the specimens belong to this group, but it is interesting to note that there appears to be a slight difference in the average size of specimens from different regions or possibly from different depths: the examples taken in the central part of the Arabian Sea, Sta. 96, 645–400 m. depth, and from the Gulf of Aden, Sta. 186, 600–0 m. depth, exhibited a total length that ranged from 5·033 to 5·300 mm., with an average of 5·143 mm., whereas those from the central area of the Arabian Sea, Sta. 172, 850–0 m. depth, exhibited a total length that ranged from 4·750 to 5·633 mm., with an average of 5·254 mm. The proportional lengths of the anterior and posterior regions of the body are as 82 to 18.

f. *major*.

♀. Two examples of this form were taken, one at Sta. 96, 645–400 m. depth, and the other at Sta. 131, 1500–0 m. depth; of these two the former measured 6·250 mm. and the latter 6·718 mm., the average of the two being 6·484 mm. Here again it seems probable that the larger specimen came from a greater depth than the smaller. The proportional lengths of the anterior and posterior regions of the body are as 81 to 19.

Apart from size the only valid difference between these two forms that I have been able to discover is the presence in f. *minor* of a row of spines on the ventro-posterior surface of the 1st segment of the 1st antenna near the distal margin: no such row has been detected in f. *major* (*cf.* Text-fig. 37, B and D).

♂. Total length, 4·5 mm.

A. Scott gives the length of his specimens from the Malay Archipelago as 5·75 mm.

The proportional lengths of the anterior and posterior regions of the body are as 74 to 26. The proportional lengths of the various segments are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
510	82	63	46	39	28	79	57	57	9	30	= 1000

In its general characters the body agrees with A. Scott's description and figures.

In this sex (Text-fig. 38, A) the muscular development of the cephalothoracic region is far more powerful than in the female; this is notably the case in the musculature of the mouth-parts and especially of the mandible. In order to provide attachment for the posterior muscle an "apodeme" has been developed on the inner aspect of the dorsal surface, a little in front of the hinge-joint between the 1st and 2nd thoracic segments; probably this infolding of the chitin is situated along the line of fusion of the cephalon and 1st thoracic segment. This increase in the musculature of the mouth-parts is all the more peculiar in view of the fact that in the male the mouthparts are to some extent degenerate.

Text-fig. 38.—*Lophothrix frontalis* Giesbrecht, ♂. A, Lateral view. B, 1st maxilla. C, 2nd maxilla. D, Maxilliped. E, 2nd leg. F, 4th leg.

The 1st antenna reaches back to the posterior border of the 1st abdominal segment. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–12.	13.	14.	15.	16.	17.	18.	19.	20–21.	22.
Right	58	48	23	23	25	23	24	194		46	52	58	63	63	59	77	35
Left	58	48	23	23	25	23	24	148	47	49	51	58	62	62	59	77	33

23.	24.	25.	
57	52	20	= 1000
58	52	20	= 1000

In both antennules the 8th to 13th segments are fused, but in the left appendage a trace of the fusion of the 12th and 13th segments can be clearly seen: segments 14 and 15 are also partly fused; segments 20 and 21 are completely fused and segments 24 and 25 partly so.

In the 2nd antenna the setæ of the row on the inner margin of the 1st basal segment are much stronger than in the female.

According to A. Scott (1909, p. 100) "the antennæ, mandibles, maxillæ and maxillipeds are nearly similar to those of the female and are only slightly modified." Unfortunately, with the exception of the terminal portion of the 2nd maxilla (1st maxilliped) he does not figure these appendages.

The mandibular palp closely resembles that of the female, but I was not successful in removing the biting ramus and so am unable to compare it with that of the female.

The 1st maxilla (Text-fig. 38, B) is less strongly developed, and there is a quite marked reduction in the number of setæ on the various lobes.

	Female.	Male.
Li. 1 . .	13	? ; the setæ are slender and delicate.
Li. 2 . .	2	?
Li. 3 . .	4	1 or 2
Basal 2 . .	5	1
Endopod .	3, 5	2, 5
Exopod .	9	9
Le. 1 . .	9	9

In the 2nd maxilla (Text-fig. 38, C) there is a general resemblance to the female, but here too the setæ are reduced in number and are much less developed. The number of setæ arising from the various lobes is as follows:

	Female.	Male.
Lobe 1 . . .	4 + 1 very small.	2
,, 2 . . .	3	2
,, 3 . . .	3	2
,, 4 . . .	3	2 + 1 small.
,, 5 . . .	3	2 + 1 small.

The terminal portion bears 8 setæ that are modified, but I was unable to convince myself that any of these possessed flame-like endings such as are found in the female.

In the maxilliped (Text-fig. 38, D) the general shape agrees with that of the female, but the 1st basal segment bears only 2 setæ at the distal end and none on the proximal portion of the segment, and the 2nd basal segment has 3 setæ on the upper margin and 2 at the distal end as in the female. The external setæ on segments 4 and 5 of the endopod are markedly enlarged and recurved.

The swimming legs (Text-fig. 38, E, F) resemble those of the female.

Distribution.—In the Atlantic Ocean this species has now been recorded from the deep waters of the Faroe Channel (T. Scott), off the south-west of Iceland (With) and the west coast of Greenland (Jespersen), the north-west part of the North Atlantic (Rose, Murray and Hjort), the west coast of Ireland and the Bay of Biscay (Farran), the temperate region of the North Atlantic (Sars, Rose) and in the South Atlantic (Wolfenden). In

the Indian Ocean it has been recorded from the central and southern areas of the Arabian Sea (present record), the Maldive region (present record) and the Bay of Bengal (Sewell). In the Pacific it has been taken in the Malay Archipelago (A. Scott), in the San Diego region of the Californian coast (Esterly), and off the west coast of America (Giesbrecht).

It is a deep water species, and its depth destribution would appear to range from about 400 to 2000 metres.

Lophothrix humilifrons Sars. (Text-fig. 39, A.)

Lophothrix humilifrons, Sars, 1925, p. 166, pl. xlvi, figs. 15–22.

Occurrence.—Sta. 61 A, Gulf of Oman, 1500–0 m., 1 female.

Remarks.—♀. This single specimen, an adult, agrees extremely closely with the description given by Sars.

The total length is 5·913 mm., which is slightly smaller than Sars' examples. The proportional lengths of the cephalothorax and abdomen are as 77 to 22, and, according to Sars, the abdomen is a little more than a quarter the length of the cephalothorax.

The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
350	186	106	80	35	20	95	44	34	24	26 = 1000

The cephalon and 1st thoracic segment are almost completely fused, but a faint line of fusion can be traced across the dorsal region. Similarly the 4th and 5th thoracic segments are almost completely fused, only a faint line indicating their respective limits. The genital segment is very nearly equal in length to the three following segments together. The furcal rami are as broad as long and are hairy on their inner aspects.

The 1st antenna reaches back to the anal segment. The various segments have the following proportional lengths :

Segment 1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
64	64	28	28	28	28	28	64	31	34	38	45	52	48	48	52	52	48

20.	21.	22.	23.	24.	25.
39	39	34	39	48	21 = 1000

The 2nd antenna, mouth parts and swimming legs appear to be extremely similar to those of *Lophothrix frontalis*.

The genital aperture, however, presents certain differences, as will be seen from a comparison of Text-figs. 37, A, C, and 39, A.

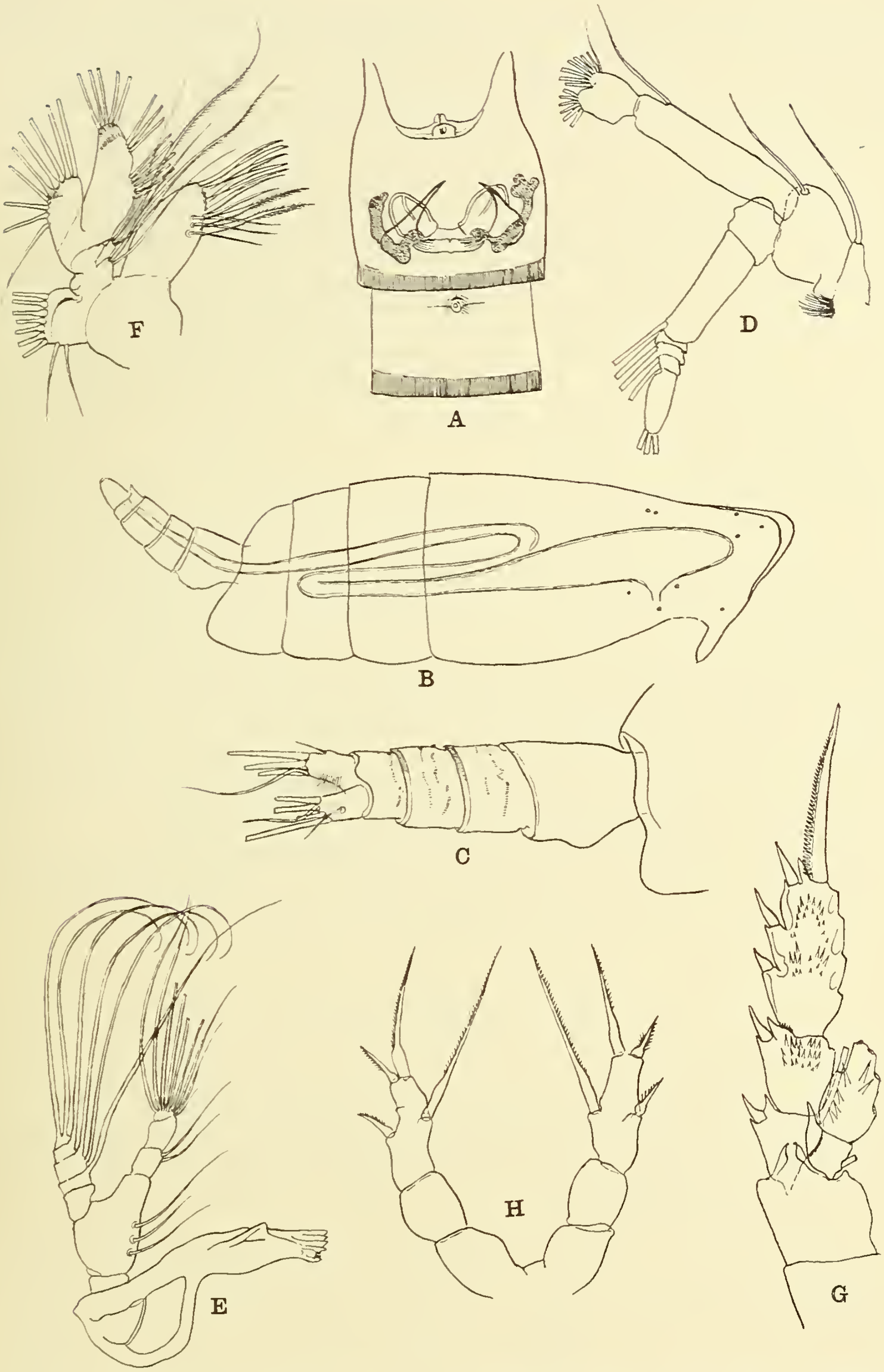
Distribution.—This species has hitherto been known only from West Greenland (Jespersen) and the Azores (Sars) in the North Atlantic. The present record extends its range to the Gulf of Oman.

Lophothrix quadrispinosa Wolfenden. (Text-fig. 39, B–H.)

Lophothrix quadrispinosa, Wolfenden, 1911, p. 269, pl. xxxiv, fig. 3 ; Sewell, 1929, p. 200, text-fig. 74, *a–f*.

Occurrence.—Sta. 172, Central area of Arabian Sea, 850–0. m., 4 females.

Descriptive Notes.—Total length, 5·483 mm.



TEXT-FIG. 39.—*Lophothrix humilifrons* Sars, ♀. A, Genital segment, ventral view. *Lophothrix quadrispinosa* Wolfenden, ♀. B, Lateral view. C, Abdomen, dorso-lateral aspect. D, 2nd antenna. E, Mandible. F, 1st maxilla. G, 2nd leg. H, 5th pair of legs.

The proportional lengths of the anterior and posterior regions of the body are as 82 to 18. The proportional lengths of the various segments of the body are as follows :

Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
553	98	76	76	78	38	30	21	30 = 1000

A few scattered pores are present in the chitinous covering of the head region. With (1915, p. 212) has called attention to the manner in which the alimentary canal of *Lophothrix frontalis* is flexed : he remarks, " the intestinal tract is curiously twisted. In front of the œsophagus a short cæcal sac is observed ; behind the stomach is gradually attenuated and forms a slight ventral convexity. At the insertion of the third pair of legs the intestine is suddenly, in a sharp bend, turned upwards and directed forwards, being thus placed dorsally to the mentioned part : somewhat in front of the maxillipeds it is continued through a second curvature into the intestine proper." The same condition is present in the present species (Text-fig. 39, B).

The three posterior segments of the abdomen (Text-fig. 39, C) are ornamented on their dorsal and dorso-lateral aspects with rows of fine hair-like spines, very similar to the ornamentation already recorded in *Lophothrix frontalis* (*vide* Sewell, 1929, p. 197).

In the present specimens the terminal segment of the 5th leg (Text-fig. 39, H) is very considerably longer than is shown by Wolfenden (*loc. cit.*, pl. xxxiv, fig. 3), and than in the specimens taken by me previously in the Bay of Bengal (Sewell, 1929, text-fig. 74, *e*). It is very much longer than the 2nd segment, and the portion distal to the 1st inner and outer spines is as long as the proximal part of the segment. The proportional lengths of the four spines also present differences in that the two outer spines are very considerably shorter than the terminal or the inner spines : in this respect these specimens approach more nearly to the condition present in *Lophothrix similis* Wolfenden.

Distribution.—Previously recorded from the South Atlantic Ocean (Wolfenden) and the Bay of Bengal (Sewell). The present record, the Arabian Sea, partially bridges the gap between the two earlier records.

Genus *Amallothrix* Sars.

Amallothrix, Sars, 1925, p. 176.

Throughout the genus there appears to be a gradual reduction in the number of setæ that spring from the various parts of the 1st maxilla in the female : in a previous paper (Sewell, 1929, p. 221) I have called attention to this in three species, and in the table below I have added two others :

1st maxilla.	*validus.*	*gracilis.*	*emarginata.*	*arcuata.*	*indica.*
Le. . . .	9	—	9	9	7
Li. 1 . .	12	12	12	11	10
Li. 2 . .	2	2	2	2	2
Li. 3 . .	4	4	4	3	3
Basal 2 . .	5	5	4	4	4
Endopod . .	8	8	7	7	6
Exopod . .	9	9	9	9	8

In many of the species of the genus the basal segments of the 2nd–4th swimming legs are ornamented with a pattern composed of minute spinules, very similar to that found in *Lophothrix frontalis*, and on basal 2 in *Scaphocalanus magnus* f. *major*. The sole exception to this among the species that I have examined is *Amallothrix indica*, in which I have been unable to detect any such ornamentation.

Amallothrix arcuata Sars. (Text-figs. 40, A–E : 41, A–J.)

Amallothrix arcuata, Sars, 1925, p. 185, pl. li, figs. 14–21 ; Sewell, 1929, p. 217.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 2 females, 1 male.

Descriptive Notes.—♀. Total length, 2·5 mm.

This is slightly smaller than Sars' examples from the North Atlantic, which measured 2·8 mm. in length.

The proportional lengths of the various segments of the body are as follows :

Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
492	98	97	90	85	42	42	18	36 = 1000

The head and 1st thoracic segment are fused. The forehead is vaulted and broadly rounded. The 4th and 5th thoracic segments are fused and the posterior thoracic margin is rounded, but there is a slight emargination in the dorso-lateral region and just above this the margin is thickened. The genital segment of the abdomen is equal in length to the two following segments, and is slightly prominent ventrally.

The 1st antenna reaches back to about the 4th segment of the abdomen. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
	57	46	25	25	25	23	25	45	22	22	25	32	39	46	57	60	62	56

20.	21.	22.	23.	24–25.
52	55	52	69	80 = 1000

The 8th and 9th and the 24th and 25th segments respectively are fused. Segment 1 bears a transverse row of hairs on its posterior aspect near the distal border.

The 2nd antenna and mouth parts closely resemble those of other members of the genus. The exopod of the 2nd antenna is longer than the endopod, and this latter bears 8 setæ on the inner lobe and 7, one of which is very small, on the outer. The 1st segment of the exopod shows no trace of the small papilla that is present in *A. emarginata* and *A. indica*. The 1st basal segment carries a row of hairs on its inner aspect.

The mandible is similar to that of *A. emarginata*.

The 1st and 2nd maxillæ (Text-fig. 40, A) show no difference from those of other members of the genus ; in the latter appendage the terminal segments bear several brush-like sensory organs, as well as two or more long cylindrical ones.

In the 1st leg the endopod consists of a single segment. Each of the three segments of the exopod bears a marginal spine.

In the 2nd and 3rd legs (Text-fig. 40, B, C) the 1st segment of the exopod is armed with a long curved marginal spine that closely resembles that of *A. falcifer* (Farran) and *A. valida* (Farran).

In the 3rd leg the 2nd basal segment bears near the articulation with the exopod a patch of medium-sized spines, similar to that in *A. gracilis* Sars.

The basal segments, especially the 2nd, and the segments of the exopod of the 3rd and 4th legs (Text-fig. 40, D, E) are richly ornamented with patches of minute scales, that appear to be rounded and resemble fish-scales. This ornamentation is on the anterior aspect of the limb, the stouter spines being borne on the posterior aspect.

The 5th leg (Text-fig. 40, E) agrees closely with the figure given by Sars.

TEXT-FIG. 40.—*Amallothrix arcuata* Sars, ♀. A, 2nd maxilla. B, 2nd leg. C, 3rd leg. D, 4th leg. E, 5th leg.

Associated with the 2 females was a single male, that seems to me to be the hitherto unknown male of this species.

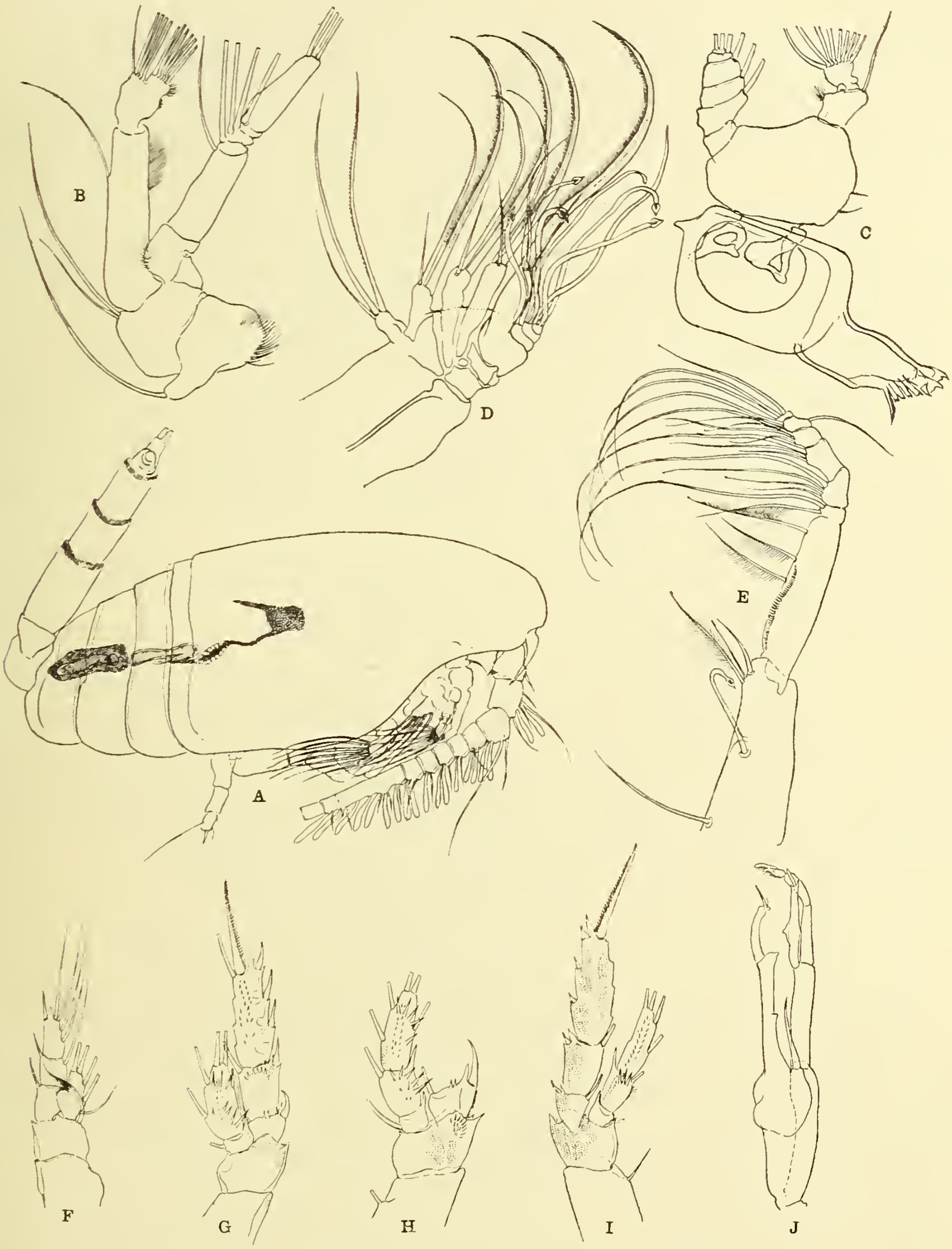
♂. Total length, 3·0 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon and Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
512	54	54	54	38	120	65	65	16	22 = 1000

The forehead (Text-fig. 41, A) is vaulted and bluntly rounded, the rostrum is depressed. The cephalon and 1st thoracic segments are fused. Immediately in front of the posterior

margin there is a line of thickening across the dorsal aspect that is continued down the lateral region but fades out before reaching the ventro-lateral margin ; possibly this represents the line of fusion, but if so the 1st thoracic segment is very narrow in comparison



TEXT-FIG. 41.—*Amallothrix arcuata* Sars, ♂. A, Lateral view. B, 2nd antenna. C, Mandible. D, 2nd maxilla. E, Maxilliped. F, 1st leg. G, 2nd leg. H, Basal segments, and endopod, 3rd leg. I, 4th leg. J, 5th pair of legs.

with the following segments. The 4th and 5th thoracic segments are fused and the posterior margin is rounded, but there is a very shallow emargination in the dorso-lateral region ; a fine line of fusion runs close to the posterior margin.

The 1st antenna is, unfortunately, broken off on both sides. The proximal segments are densely provided with sensory processes, as a rule 2 arising from each segment. Segments 9 to 13 are fused completely and the separation of 13 and 14 is incomplete.

In the 2nd antenna (Text-fig. 41, B) the exopod is considerably longer than the endopod, over-reaching it by the terminal segment ; segment 1 of the exopod is armed with scattered hair-like spinules. The 1st basal segment bears a row of hairs on its inner aspect.

The mandible (Text-fig. 41, C) is well developed, and it is of interest to note that between the basal part of the biting ramus and the inflated segment bearing the two rami there is a small but fully chitinized segment, which supports the contention that there are three segments in the basal part of this appendage.

The 1st maxilla appears to be identical with that of the female.

The 2nd maxilla (Text-fig. 41, D) is also very similar to that of the female.

The maxilliped (Text-fig. 41, E) is fully developed, and resembles that of the female.

The swimming legs (Text-fig. 41, F–I) show a close agreement with those of the female, even to the number and arrangement of the spinules on the various segments of the rami.

The 5th pair of legs (Text-fig. 41, J) possesses the same basic arrangement as in *Amallothrix obtusifrons* and *A. gracilis*, but differs from both these species in details of structure.

DISTRIBUTION.—This species has now been recorded from the North Atlantic (Sars) ; the Arabian Sea (present record) and the Laccadive Sea (Sewell).

Amallothrix emarginata (Farran). (Text-fig. 42, A–F.)

Scolecithrix emarginata, Farran, 1905, p. 36, pl. viii, figs. 6–17.
Scolecithricella obtusifrons, A. Scott, 1909, p. 92, pl. xxxi, figs. 1–9.
Scaphocalanus obtusifrons, With, 1915, p. 194, text-figs. 60, 61, pl. vii, figs. 9 *a–d*, pl. viii, figs. 8, *a–e*.
Amallothrix emarginata, Sars, 1925, p. 181, pl. l, figs. 17–23.
? *Scolecithrix inornata*, Esterly, 1906, p. 67, pl. ix, fig. 18, pl. xi, fig. 37, pl. xiii, figs. 65, 73.
? *Scolecithrix æqualis*, Wolfenden, 1911, p. 255, text-fig. 33, *a–c*.

OCCURRENCE.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

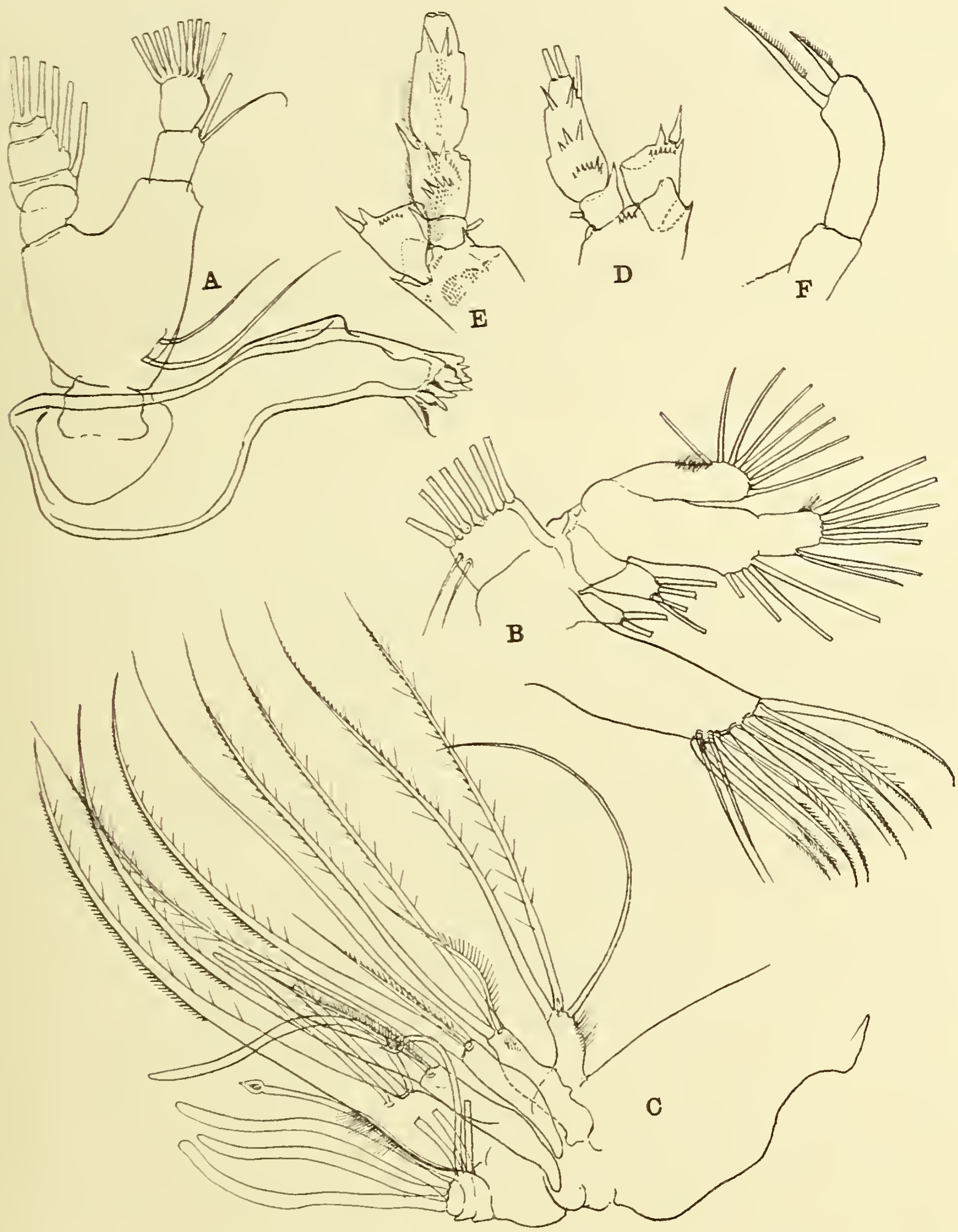
DESCRIPTIVE NOTES.—♀. Total length, 4·3 mm.

This agrees exactly with A. Scott's examples from the Malay Archipelago.

The proportional lengths of the anterior and posterior regions of the body are as 81 to 19. Wolfenden (1911, p. 255) gives the total length of the example that he named *Scolecithrix æqualis* as 3·65 mm., which is somewhat smaller than the present example, but he gives the proportional lengths of the two regions of the body as 2·95 and 0·7 mm., which agrees exactly with the proportions given above, namely, 81 to 19.

The body tapers somewhat anteriorly. The 5th thoracic segment is partially separated off from the 4th as a narrow strip along the posterior margin. The posterior margin when viewed from the side is emarginate : Wolfenden states that in *S. æqualis* the 4th and 5th segments are fused, and he figures them as being uniformly rounded postero-laterally.

In the abdomen the proportional lengths of the segments are as 38, 22, 22, 8, 10. In the 2nd and 3rd segments the proportions of length to breadth are as 5 to 7 and 5 to 6·5 respectively.



TEXT-FIG. 42.—*Amallothrix emarginata* (Farran), ♀. A, Mandible. B, 1st maxilla. C, 2nd maxilla. D, Basal region and endopod of 2nd leg. E, Basal region and endopod of 3rd leg. F, 5th leg.

The 1st antenna differs on the two sides. Wolfenden, in his account of *S. æqualis*, states that the appendage on the right side is composed of 23 segments, while that on the left has only 22 ; in the present specimen the opposite is the case, the right antennule possessing only 22 segments, while the left has 23. The proportional lengths of the

segments are given below, and for the purpose of comparison I have given the lengths, as stated by Farran in his specimens, recalculated as parts per 1000.

Segment	1.	2.	3.	4.	5.	6.	7.	8–9.	10.	11.	12.	13.	14.	15.	16.	17.
Present example	68	58	30	28	29	25	25	40	25	28	32	46	49	50	51	50
From Farran	51	51	26	26	26	23	21	38	26	30	34	51	53	53	53	53

	18.	19.	20.	21.	22.	23.	24. 25.	
Present example	50	49	49	47	49	58	64	= 1000
From Farran	53	53	53	49	51	60	66	= 1000

Wolfenden gives the lengths of the last five segments in *æqualis* as 25, 24, 19, 20, 20 ; at first sight these figures exhibit marked differences from either Farran's account of *emarginata* or the present specimen ; but I believe that Wolfenden has given the lengths in the inverse order, commencing from the end segment, and, if so, the proportional lengths of these segments, as recalculated to the same scale as those given above, would read thus—

20.	21.	22.	23.	24–25.
49	49	47	59	62

The 1st segment bears a transverse row of hairs distally and parallel to the distal margin.

In the 2nd antenna the 1st basal segment bears a row of long hairs on its inner border : the proportional lengths of the rami agree with the accounts given by previous authors ; the 1st segment of the exopod is produced in a small rounded prominence on its anterior margin near the distal border.

The mandible (Text-fig. 42, A) is a powerful biting organ. With (1915, p. 194) states that this appendage is " scarcely different from those of *S. magnus*," but a comparison of the two shows that in the present form the two rami of the palp are of approximately equal length, whereas in *S. magnus* the endopod is only about half the length of the exopod.

In the 1st maxilla (Text-fig. 42, B) Farran figures only 7 large setæ arising from the 1st outer lobe ; With states that there are in his examples 7 long setæ and a shorter, more delicate one : in the present specimen there are two short, delicate setæ, in addition to the 7 large ones. The 1st inner lobe bears 12 setæ, that are slightly shorter than the lobe itself ; the 2nd inner lobe has 2 setæ and the 3rd inner lobe 4. The basal segment bears only 4 setæ, exopod 1 has 2 setæ, and endopod 2–3 bears 5. The exopod carries 8 setæ and the outer border is hairy.

The 2nd maxilla (Text-fig. 42, C) and maxilliped agree with the figures given by Farran, except that the 2nd basal segment of the maxilliped bears a sensory appendage, thus agreeing with With's specimen.

The swimming legs in the present specimen are badly damaged ; but sufficient remained to indicate that they agree closely with the description given by With. In addition to the minute spinules on the anterior face of the endopod of the 3rd leg, to which With has called attention, there are also patches of similar minute spinules on the 2nd basal segment (Text-fig. 42, E).

The 5th legs (Text-fig. 42, F) agree with the descriptions of previous authors.

Remarks.—With (1915, p. 197) has pointed out that " this species is nearly related

to, if not identical with, Wolfenden's *S. æqualis* from the South Atlantic, as well as with *S. inornata* Esterly, but the descriptions are too insufficient for solving the question." The manner in which the above specimen agrees with Wolfenden's account of *S. æqualis*, especially in respect to the asymmetry of the 1st antenna, strengthens the belief that *æqualis* is a synonym of *emarginata*.

Distribution.—Assuming that *Scolecithrix inornata* Esterly and *S. æqualis* Wolfenden are synonyms of *Amallothrix emarginata* Farran, this species would appear to have a very wide distribution, ranging in the Atlantic Ocean from the Faroe-Iceland channel, off the south of Iceland, and Denmark Strait (With), to the west coast of Ireland (Farran, Pearson), the Woods Hole region (Wilson), the Gulf of Maine (Bigelow), the temperate North Atlantic (Sars, Lysholm and Nordgaard, Rose) and the tropical Atlantic region (Wolfenden). In the Indian Ocean from the Arabian Sea (present record) and the Laccadive Sea (Sewell). In the Pacific Ocean from the Malay Archipelago (A. Scott) and the San Diego region of the coast of California (Esterly).

Amallothrix gracilis Sars. (Text-fig. 43, a–f.)

Scolecithricella gracilis, Sars, 1905, p. 21.
Scolecithrix globiceps, Farran, 1906, p. 54, pl. v, figs. 8–13, pl. vi, fig. 8.
Amallothrix gracilis, Sars, 1925, p. 176, pl. xlix, figs. 9–21.
Scaphocalanus globiceps, With, 1915, p. 199, text-fig. 63, *a*, *b*; pl. vii, figs. 10, *a*, *b*; pl. viii, figs. 9, *a–c*.
? *Scolecithricella gracilis*, A. Scott, 1909, p. 93, pl. xxxi, figs. 8–13.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

Remarks.—I have no hesitation in referring this specimen to Sars' species: I am, however, doubtful whether the form described by A. Scott (1909) from the Malay Archipelago is actually an example of this species, for in the 2nd leg (Text-fig. 43, c) he figures on the 2nd segment of the exopod a double row of spinules along the distal border, whereas in my example, and in other authors' descriptions and figures, only a single row is present in this situation. Again, in the 5th leg (Text-fig. 43, f) the small external marginal spine arises in Scott's example much nearer the proximal end of the segment, markedly proximal to the point of origin of the inner spine, whereas in the true *gracilis* the origins of these two spines are nearly opposite each other: and finally, the portion of the ramus that is distal to the origin of the inner spine appears to be much longer in Scott's specimen than in true examples of *A. gracilis*.

Distribution.—This species has now been recorded from the Arabian Sea (present record), the North Atlantic Ocean near the Azores and the coast of Portugal (Sars), the west coast of Ireland (Farran) and south of Iceland (With). If A. Scott is correct in his identification the species also occurs in the Malay Archipelago.

Amallothrix indica Sewell.

Amallothrix indica, Sewell, 1929, p. 219, text-fig. 81 *a–g*.

Occurrence:

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.
Sta. 96, Central part of Arabian Sea, 645–400 m., 5 females.
Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

Remarks.—The total length of these specimens ranged from 3·233 to 3·40 mm. They are thus slightly larger than the specimens previously recorded by me from the Laccadive Sea.

Text-fig. 43.—*Amallothrix gracilis* Sars, ♀. A, 2nd antenna. B, Maxilliped. C, 2nd leg. D, 3rd leg. E, Proximal part of 4th leg. F, 5th leg.

Distribution.—This species has now been recorded from the Laccadive Sea (Sewell) and the central and northern parts of the Arabian Sea (present records).

Family Centropagidæ.

Genus *Centropages* Kröyer.

Centropages, Giesbrecht, 1892, p. 303.

Centropages calaninus (Dana).

Centropages calaninus, Giesbrecht, 1892, p. 305, pl. xvii, figs. 27, 28, 42; pl. xviii, fig. 11; pl. xxxviii, figs. 1, 21; Wolfenden, 1906, p. 1014, pl. xcviii, figs. 6, 15.

Occurrence.—Sta. 61, Northern area of Arabian Sea, surface, 1 male.

Distribution.—This species, though comparatively rare, is widely distributed throughout the Indo-Pacific region. It has been recorded from the Pacific Ocean (Dana, Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott), the Bay of Bengal (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott), the Maldive and Laccadive Archipelagoes (Thompson and A. Scott, Wolfenden), the Arabian Sea (Cleve, Thompson and A. Scott, present record), the Red Sea (A. Scott) and the South Atlantic Ocean, in 26° 50′ S. (T. Scott).

Centropages gracilis (Dana).

Centropages gracilis, Giesbrecht, 1892, p. 305, pl. xvii, figs. 31, 32, 46, pl. xxxviii, figs. 4, 13; Wolfenden, 1906, p. 1013, pl. xcviii, fig. 7.

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, surface, numerous examples, 2000–0 m., 1 female, 1 male.

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female.

Remarks.—The specimens, noted above, that were taken in the nets from deep hauls were almost certainly caught near the surface as the net was being hauled.

The dorsal region of the 1st–4th thoracic segments is ornamented by clumps of fine needle-like spinules.

Distribution.—In the Pacific Ocean on the east side (Dana), and on the west (Giesbrecht), on the Australian Barrier Reefs (Farran), and in the Malay Archipelago (A. Scott). In the Indian Ocean on the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), in the Laccadive Sea (Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present records), the Red Sea (Thompson and A. Scott), and in the South Atlantic Ocean in about lat. 28° S. (Wolfenden).

Centropages orsinii Giesbrecht.

Centropages orsinii, Giesbrecht, 1892, p. 305, pl. xvii, figs. 35, 36, 41, 42, pl. xviii, figs. 2, 14, 23, pl. xxxviii, figs. 12, 19; Wolfenden, 1906, p. 1015, pl. xcviii, figs. 1, 4, 5, 8, 11, 12, 13.

Occurrence.—Sta. 61, Northern part of Arabian Sea, surface, numerous specimens.

Distribution.—The Australian Barrier Reef (Farran), the Aru Archipelago (Früchtl), the Malay Archipelago (A. Scott), the coast of Burma (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Madras coast (Menon), the Maldive and Laccadive

Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, Pesta, present record), the Persian Gulf (Pesta), the Gulf of Aden (A. Scott), the Red Sea (Giesbrecht), Durban Bay (Brady).

Family Pseudodiaptomidæ.

Genus *Schmackeria* Poppe and Richard.

Schmackeria, Poppe and Richard, 1890, p. 1 ; Marsh, 1933, p. 41.

Schmackeria serricaudatus (T. Scott).

Heterocalanus serricaudatus, T. Scott, 1894, p. 40, pl. ii, figs. 43–48 ; pl. iii, figs. 1–7.
Pseudodiaptomus serricaudatus, A. Scott, 1902, p. 404, pl. i, fig. 6.
Schmackeria serricaudatus, Marsh, 1933, p. 46, pl. xxii, figs. 2, 3.

Occurrence :

Sta. 56, South Arabian Coast, surface, several examples.

Sta. 58, South Arabian Coast, surface, several examples.

Distribution.—The Chilka Lake (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the west coast of India (Cleve), the Arabian Sea (Thompson and A. Scott), the South Arabian Coast (present records), the Gulf of Aden (Thompson and A. Scott), the Red Sea (A. Scott), south of Cape Colony (Cleve), and the Gulf of Guinea (T. Scott). It would thus appear to be an Indian Ocean form that has managed to get round the Cape of Good Hope into the Gulf of Guinea, where it was originally taken.

Genus *Pseudodiaptomus* Herrick.

Pseudodiaptomus, Herrick, 1884, p. 180 ; Marsh, 1933, p. 27.

Pseudodiaptomus salinus (Giesbrecht).

Schmackeria salina, Giesbrecht, 1896, p. 322, pl. vi, figs. 23–28.
Pseudodiaptomus salinus, Thompson and A. Scott, 1903, p. 248, pl. ii, figs. 21–23 ; Marsh, 1933, p. 39, pl. xx, figs. 4, 5.

Occurrence.—Sta. 56, South Arabian Coast, surface, 1 male.

Distribution.—The Nicobar Islands (Sewell), the Arabian coast (present record), the Red Sea, Gulf of Suez, and Suez Canal (Thompson and A. Scott, Gurney).

Family Temoridæ.

Genus *Temora* Baird.

Temora, Giesbrecht, 1892, p. 329 ; Giesbrecht and Schmeil, 1898, p. 100.

Temora discaudata Giesbrecht.

Temora discaudata, Giesbrecht, 1892, p. 328, pl. xvii, figs. 3, 20, 23 ; pl. xxxviii, figs. 24, 25, 28 ; Sewell, 1912, p. 365, pl. xxii, figs. 8, 9.

Occurrence.—Sta. 56, South Arabian Coast, surface, 5 males.

Distribution.—Widely distributed throughout the Pacific and Indian Oceans and

in the Mediterranean Sea. It has been reported from the whole width of the Pacific Ocean between lats. 9° S. and 20° N., and from New Holland, the Philippine Islands, Fiji and the Kei Islands (Giesbrecht), the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl), the Malay Archipelago (Cleve, A. Scott), the coast of Southern Burma and the Nicobar Islands (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Cleve), the coast of Southern Arabia (present record), the Persian Gulf (Pesta), the Gulf of Aden (Thompson and A. Scott), the Red Sea (Giesbrecht, Thompson, A. Scott), the Suez Canal (Gurney), the Mediterranean Sea (Thompson and A. Scott), and the Agulhas current east of Cape Colony (Cleve).

Temora turbinata (Dana).

Temora turbinata, Giesbrecht, 1892, p. 329, pl. xvii, figs. 14, 17, 18, 21 ; pl. xxxviii, fig. 27 ; Wilson, 1932, p. 106, fig. 71, *a–c*.
Temora longicornis, T. Scott, 1894, p. 76, pl. ix, fig. 13.
Temora tenuicauda, Brady, 1899, p. 34, pl. ix, figs. 16–23.
Temora africana, Brady, 1914, p. .

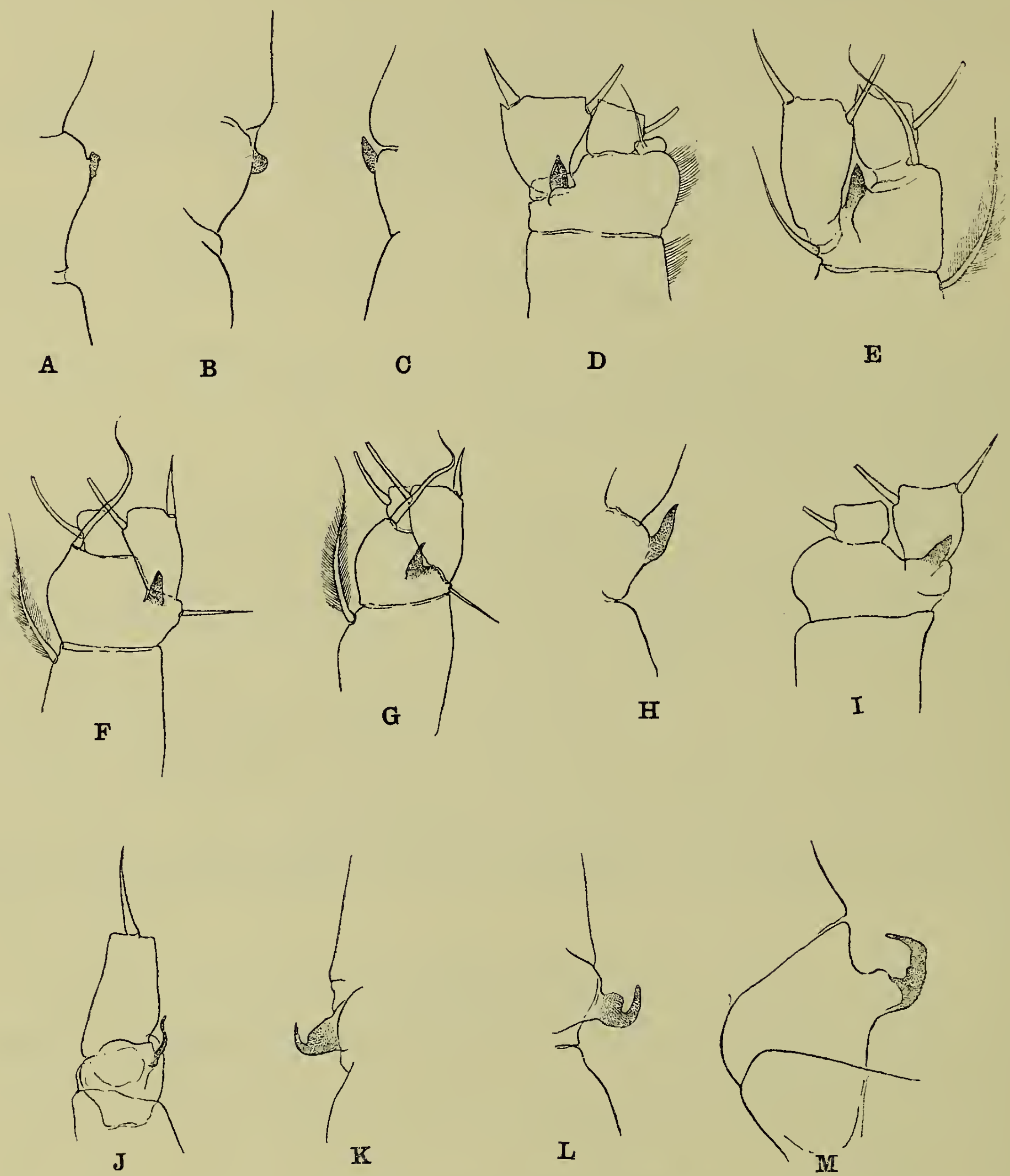
Occurrence.—Sta. 56, South Arabian Coast, surface, 3 females, 2 males.

Distribution.—Like the preceding species, this is widely distributed throughout the western part of the Pacific Ocean and throughout the Indian Ocean, and has spread into the Atlantic Ocean. It has been recorded from Hong Kong (Giesbrecht), the Sulu Sea (Dana), the coast of New Zealand (Brady, as *T. tenuicauda* ; Farran), the Australian Barrier Reefs (Farran), Aru Archipelago (Früchtl), the Malay Archipelago (Cleve), Kurau River, Penang (Sewell), the coast of Southern Burma (Sewell), the Madras Coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Arabian Sea (Pesta), the Persian Gulf (Pesta), the coast of South Arabia (present record), near Durban Bay, E. Africa (Brady, as *T. africana*), the Gulf of Guinea (T. Scott), the North Atlantic Ocean (T. Scott, Sars), the Gulf of Maine (Bigelow) and the Woods Hole region of North America (Wilson).

Family Metridiidæ.

In the Family Metridiidæ and the closely related Families Lucicutiidæ and Heterorhabdidæ we have a group of genera in which there is a marked degree of development of the cutaneous glands both on the appendages and on the segments of the body. Giesbrecht (1895) has called attention to these glands in the genera *Metridia*, *Lucicutia*, *Pleuromamma* and *Heterorhabdus*, and he has pointed out that some, at least, of these glands produce a luminescence. Similar enlarged glands are also to be seen in the genus *Gaussia* (*vide* Sewell, 1932, p. 271, fig. 92), *Hemirhabdus* (*loc. cit.*, p. 303, fig. 99), *Mesorhabdus* and *Disseta* (*loc. cit.*, p. 310, fig. 102), as well as in the genera *Arietellus* and *Phyllopus*. It is interesting to note that in all these genera there is on the posterior aspect of the 2nd basal segment of the 1st leg a hook-like or spine-like process. Giesbrecht (1892) has observed this process in some of these genera, *viz.*, *Metridia*, *Pleuromamma* and *Phyllopus*. The shape of the process shows some variation in the different genera, but it is undoubtedly homologous throughout the whole series (Text-fig. 44, A–M). It appears to be least developed

in the genus *Metridia,* and Giesbrecht remarks that it is marked only in *M. normani ;* in *M. princeps* it forms only a small rounded projection ; in *Pleuromamma, Lucicutia* and *Hemirhabdus,* as well as in *Phyllopus* and *Pachyptilus,* it takes the shape of a triangular



Text-fig. 44.—Process on the posterior aspect of the 2nd basal segment in different species : A, *Metridia princeps.* B, *Heterostylites longicornis.* C, *Lucicutia flavicornis.* D, *Lucicutia challengeri.* E, *Pyhllopus muticus.* F, *Pleuromamma abdominalis.* G, *Pleuromamma xiphias.* H, *Pleuromamma indica.* I, *Pachyptilus eurygnathus.* J, *Disseta palumboi.* K, *Heterorhabdus abyssalis.* L, *Heterorhabdus spinifrons.* M. *Mesorhabdus angustus.*

pointed process ; and in *Disseta, Heterorhabdus* and *Mesorhabdus* it presents a swollen base from which arises a tapered flagellum, delicate in *Disseta* but stout in *Mesorhabdus.* I am unable to offer any suggestion regarding the function of this organ.

Genus *Metridia* Boeck.

Metridia, Giesbrecht, 1892, p. 339; Giesbrecht and Schmeil, 1898, p. 105.

Metridia princeps Giesbrecht.

Metridia princeps, Giesbrecht, 1892, p. 340, pl. xxxiii, figs. 3, 18, 35, 40; Wolfenden, 1908, p. 15, pl. iii, figs. 3–5; A. Scott, 1909, p. 121, pl. xxxviii, figs. 1–7; Sars, 1925, p. 194, pl. liiii, figs. 1–12; Wilson, 1932, p. 122, fig. 81, *a–c*; Wolfenden, 1908, p. 15, pl. iii, figs. 3–5; *idem*, 1911, p. 287, pl. xl, figs. 8–13.

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 4 females, adult, and 1 juv., 1 male, juv.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 male, adult.

Sta. 76, Gulf of Oman, 1500–0 m., 1 female.

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 male, adult.

Sta. 131 D, Southern part of Arabian Sea, 1500–0 m. vertical, 5 females, adult, 1 female, juv.

Sta. 172, Central part of Arabian Sea, 400–0 m., 1 male; 850–0 m., 3 females, adult, 1 male, adult, 1 male, juv.

Distribution.—This species is very widely distributed throughout all the great oceans. It has been recorded from the west coast of South America in lat. 3° S., long. 99° W. (Giesbrecht), the San Diego region of the Californian coast (Esterly), the Antarctic Ocean in lats. 66° 30′ to 76° S. (Farran), the Malay Archipelago (A. Scott), the Bay of Bengal and Laccadive Sea (Sewell), the Arabian Sea (present records), east of Cape Colony (Cleve), the South Atlantic (Wolfenden), the North Atlantic (Sars, Lysholm and Nordgaard, Rose), the Bay of Biscay and the west coast of Ireland (Farran), the Gulf of Maine (Bigelow), the Woods Hole region (Wilson), and to the south of Davis Strait (Jespersen).

The Depth distribution appears to be rather deep, and Wilson (1932, p. 123) suggests that "*princeps* is more of a bottom form than any other species of the genus." That it is a deep dwelling form is certain; the depths at which it has been taken in different regions is given below:

West of Greenland and in Davis Strait . .		500 to 2000 metres.
South of Iceland		1000 ,, 1300 ,,
West of Ireland		500 ,, 2100 ,,
North Atlantic	optimum	1000 ,, 2000 ,,
Bay of Biscay	optimum	550 ,, 1830 ,,
. . . . .	down to	2740 ,,
South Atlantic		1000 ,, 3000 ,,
East of Cape Colony		780 ,, 900 ,,
Arabian Sea		400 ,, 1500 ,,
. . . . .	optimum	850 ,, 1500 ,,
Laccadive Sea and Bay of Bengal . . .		730 ,, 1280 ,,
Malay Archipelago		700 ,, 1500 ,,
Antarctic Ocean		1000 ,,
East Pacific and San Diego region . .		732 ,, 1800 ,,

It has, however, on four occasions, thrice in the North Atlantic Ocean (Sars) and once in the Malay Archipelago (A. Scott), been taken on the surface.

Genus *Pleuromamma* Giesbrecht.

Pleuromamma, Giesbrecht, 1892, p. 347 ; Giesbrecht and Schmeil, 1898, p. 108.

Pleuromamma abdominalis (Lubbock).

Pleuromamma abdominalis, Giesbrecht, 1892, p. 347, pl. v, fig. 8 ; pl. xxxii, figs. 3, 5, 13, 22, 25–30 ; pl. xxxiii, figs. 43, 44, 48, 49, 52.
Pleuromamma abdominalis, Steuer, 1932, p. 9, figs. 21–51.

Occurrence :

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 2 females, 4 males, 12 juv. ; 1500–0 m., 4 females, 1 juv., male.

Sta. 145, Maldive area, 300–0 m. vertical, 1 female ; 500–0 m. vertical, 1 female.

Sta. 172, Central area of Arabian Sea, 200–0 m., 6 juv. ; 400–0 m., 21 examples ; 850–0 m., 17 examples.

Descriptive Notes.—Several different forms of this species have been described, namely—

f. *typica*.
f. *edentata*.
f. *abyssalis*, sub-f. *hypothermophila*.
sub-f. *thermophila*.

So far as I have been able to discover, all the specimens in the present collection belong to f. *typica*.

Distribution.—This species is widely distributed throughout all three great Oceans ; for details of the distribution I refer the reader to the account given by Steuer (1932, pp. 45 and 58, Charts 2–7).

Pleuromamma indica Wolfenden.

Pleuromamma indica, Wolfenden, 1906, p. 1011, pl. xcvi, figs. 24–26, 31–33 ; Sewell, 1932, p. 265, text-fig. 89, *a–f* ; Steuer, 1932, p. 17, text-figs. 52–68.

Occurrence :

Sta. 76, Gulf of Oman, 1500–0 m., 2 females.

Sta. 172, Central area of Arabian Sea, 400–0 m., 1 female ; 850–0 m., 1 male.

Distribution.—This species occurs in the Indian Ocean and its offshoots, the Gulf of Oman and Persian Gulf, and the Gulf of Aden and Red Sea. It has also been taken in the South Atlantic Ocean off the west coast of Africa. Steuer regards it as a visitor to the Atlantic. For details of its distribution I refer the reader to Steuer's account (1932, pp. 47, 61, Charts 8, 9).

Pleuromamma quadrungulata (F. Dahl).

Pleuromamma quadrangulata, Wolfenden, 1911, p. 289, text-fig. 47.
Pleuromamma quadrungulata, Dahl, 1893, p. 105 ; Sewell, 1932, p. 267, text-fig. 90, *a–e* ; Steuer, 1932, p. 26, text-figs. 92–110 ; Esterly, 1911, p. 329, pl. xxx, fig. 6 ; pl. xxxii, fig. 111.

Occurrence :

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 6 specimens ; 1500–0 m., 7 specimens.

Sta. 145 C, Maldive area, 300–0 m., vertical, 4 females.

Sta. 145 D. Maldive area. 100–0 m., vertical, 2 females, 300–0 m. vertical, 1 female : 500–0 m. vertical, 1 female, 1 male.

Sta. 172. Central area of Arabian Sea, 400–0 m., 7 specimens.

Descriptive Notes.—All examples belong to f. *typica* Steuer.

Distribution.—This species occurs in the Atlantic, Indian and Pacific Oceans. For details of its distribution I refer the reader to Steuer's account (1932, pp. 49, 63, charts 12, 13).

Pleuromamma xiphias (Giesbrecht). (Text-fig. 45, a–j.)

Pleuromamma xiphias, Giesbrecht, 1892, p. 347, pl. xxxii, fig. 14, pl. xxxiii, figs. 42, 45, 50; Wolfenden, 1906, p. 1012, pl. xcvi, figs. 27, 37–39 ; Sars, 1925, p. 202, pl. lv, figs. 1–12 ; Wilson, 1932, p. 124, fig. 82, *a*, *b* ; Sewell, 1932, p. 269, text-fig. 91 ; Steuer, 1932, p. 5, text-figs. 1–20.

Occurrence :

Sta. 96, Central part of Arabian Sea, 645–400 m., 321 females, 155 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m. vertical, 3 females, 2 males ; 1500–0 m. vertical, 17 females, 20 males.

Sta. 145 C, Maldive area, 300–0 m. vertical, 1 female, 1 male ; 500–0 m. vertical, 7 females, 5 males.

Sta. 145 D, Maldive area, 300–0 m. vertical, 3 males ; 500–0 m. vertical, 4 females, 4 males.

Sta. 172, Central part of Arabian Sea, 200–0 m., 4 females ; 400–0 m., 125 males, 97 females ; 850–0 m., 139 females, 108 males ; 2091–0 m., 1 female.

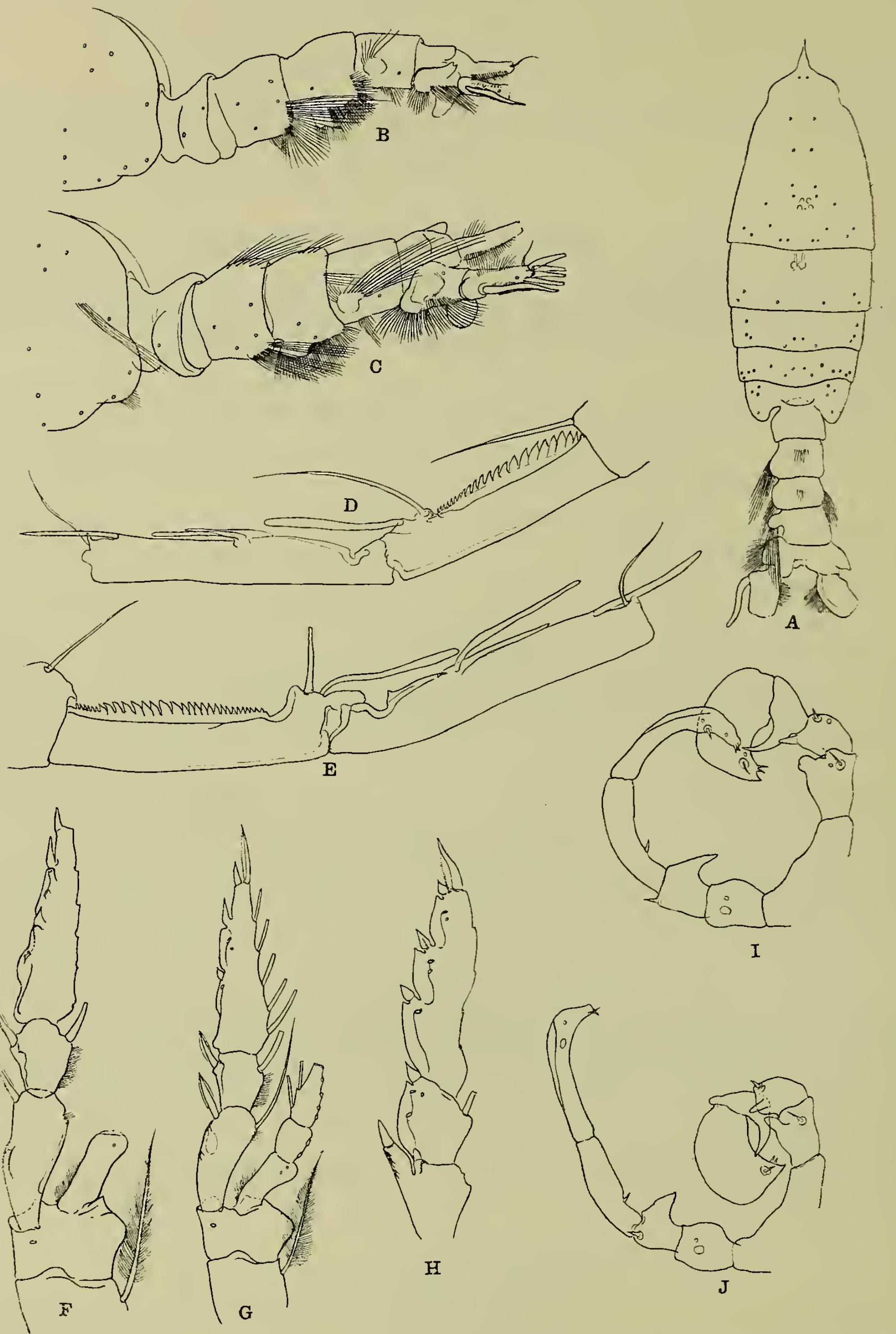
Sta. 186, Gulf of Aden, 575 and 600–0 m., 32 specimens ; 960–0 m., 33 females, 42 males.

Descriptive Notes.—Steuer (1932, p. 70) has called attention to the occurrence in this species of two groups of individuals that differ markedly from each other in size, examples of the larger size occurring in the Atlantic region and smaller specimens being taken in the Indian Ocean, while examples of both groups occur in the western part of the latter region ; he also has shown that these two size groups inhabit different water strata, the smaller forms being taken at depths of 450–550 metres and the larger forms below 600 metres. Steuer provisionally concludes that we have in this species two separate races, the larger race inhabiting the water of the Sub-polar Intermediate current and the smaller race the stratum overlying this ; within both these races there is a variation in size with the depth, those individuals occurring at higher levels being smaller than those living more deeply.

In the present collection the great majority of specimens belong to the smaller race, but a few examples of the larger race were taken at certain stations, namely :

Sta. 131	500–0 m.	1 female, 1 male.
	1500–0 m.	8 females, 9 males.
Sta. 172	850–0 m.	2 females, 4 males.

These figures definitely suggest that in the southern part of the Arabian Sea (Sta. 131) the larger race is in the main to be found at some depth below 1500 m., at which level the proportion of large and small forms is almost equal, the catch consisting of 9 females and 11 males of the small form, and 8 females and 9 males of the large, while at a level above 500 metres the catch consisted of only 2 females and 1 male of the small form, and 1 female



Text-fig. 45.—*Pleuromamma xiphias* (Giesbrecht), ♂. A, Dorsal view. B, Abdomen, lateral view, f. *minor*. C, Abdomen, lateral view, f. *major*. D, 1st antenna, hinge joint, f. *minor*. E, 1st antenna, hinge joint, f. *major*. F, 2nd leg, right side, f. *major*. ♂. G, 2nd leg, right side, f. *minor*, ♂. H, 3rd leg, exopod, f. *major*. I, 5th pair of legs, f. *major*. J, 5th pair of legs, f. *minor*.

and 1 male of the large race. Further to the north-west, at Sta. 172 in the central region of the Arabian Sea, the small form predominated, and in the catch from 850–0 metres there were 137 females and 104 males of the small form, and only 2 females and 4 males of the large.

Steuer states that in the "Valdivia" collection the smallest examples were obtained from the Gulf of Aden, and he refers to these specimens as "dwarf forms"; in the present collection the smallest examples came from the Maldive Area, Sta. 145. In the following Table I give the average sizes of both sexes in both f. *minor* and f. *major* at the various stations:

f. *minor*.

Depth. (m.)	Sta.	Average total length. Female. (mm.)	Male. (mm.)
300–0	Sta. 145, Maldive area	..	4·292
400–0	,, 172, centre of Arabian Sea	4·430	4·759
500–0	,, 145, Maldive area	4·133	4·235
500–0	,, 131, southern part of Arabian Sea	4·275	..
575–0	,, 186, Gulf of Aden	4·268	4·558
600–0	,, 186, ,, ,,	4·292	4·547
645–400	,, 96, centre of Arabian Sea	4·369	4·478
850–0	,, 172, ,, ,,	4·520	4·618
1500–0	,, 131, southern part of Arabian Sea	4·319	4·400

f. *major*.

Depth. (m.)	Sta.	Female. (mm.)	Male. (mm.)
500–0	,, 131, southern part of Arabian Sea	4·967	5·017
850–0	,, 172, centre of Arabian Sea	4·536	5·900
1500–0	,, 131, southern part of Arabian Sea	5·379	5·554

From the above there appears to be the usual correlation between depth of occurrence and size of specimens: but there is, further, a very definite correlation between size and habitat; thus the smallest examples were taken, as mentioned above, in the Maldive region. This is clearly seen if we arrange the above table in accordance with the size of the specimens as follows:

f. *minor*.

Average total length. Female. (mm.)	Male. (mm.)	Sta.	Depth. (m.)
4·133	4·235	Sta. 145, Maldive area	500–0
4·268	4·558	,, 186, Gulf of Aden	575–0
4·275	..	,, 131, southern part of Arabian Sea	500–0
4·292	4·547	,, 186, Gulf of Aden	600–0
4·319	4·400	,, 131, southern part of Arabian Sea	1500–0
4·369	4·478	,, 96, centre of Arabian Sea	645–400
4·430	4·759	,, 172, ,, ,,	400–0
4·520	4·618	,, 172, ,, ,,	850–0

f. *major*.

Average total length: Female. (mm.)	Male. (mm.)	Sta.	Depth. (m.)
4·967	5·017	Sta. 131, southern part of Arabian Sea .	500–0
5·379	5·554	,, 131, ,, ,, ,, .	1500–0
5·520	5·900	,, 172, centre of Arabian Sea . . .	850–0

It thus seems clear that both f. *major* and f. *minor* have been subjected to some adverse influence at depths ranging from 300 to 1500 metres at Stas. 96, 131, 145 and 182, and have been little if at all affected at depths of 400 to 850 metres at Sta. 172. The explanation of this would appear to be that the former Stations and depths all lie in the Indian tropical intermediate water, which is inimical to life, whereas the latter lie in the South Polar intermediate water, in which no such harmful influence can be detected.

Structurally there appears to be little difference, apart from size, between these two forms. There are, however, slight differences in the proportional lengths of the segments of the body and the segments of the 1st antenna ; the proportional lengths of the segments of the body are as follows :

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–3.	Abd. 4.	Abd. 5.	Furca.
f. *minor*	329	133	67	63	97	130	66	55	60 = 1000
f. *major*	316	120	70	64	94	126	67	55	58 = 1000

There is thus a reduction in the total length of the cephalothorax from 689 to 664 parts per 1000 of the total length, which is mainly due to the comparatively shorter cephalon and 1st thoracic segment. In the abdomen the genital segment is proportionally shorter in the large form, and the furcal ramus also seems to be slightly shorter.

In the 1st antenna of the female the proportional lengths of the various segments in the two forms are as follows :

Segment	1.	2.	3.	4.	5.	6.	7–9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
f. *minor*	82	22	23	23	27	27	43	21	27	48	39	50	54	59	62	59	55	59
f. *major*	84	23	24	26	26	26	39	21	29	50	40	52	56	61	64	61	54	58

Segment	21.	22.	23.	24.	25.
f. *minor*	40	35	44	49	52 = 1000
f. *major*	38	34	42	45	48 = 1000

There appears to be but little difference in the proximal segments, but from segment 7 to 18 each segment is proportionally slightly longer in f. *major* than in f. *minor*, whereas from segment 19 to the end of the appendage the segments are proportionally somewhat shorter in the larger form. It is interesting to note that these differences in the proportions of the two forms agree very closely with the differences that I have previously (Sewell, 1929 and 1932) shown to be present in the various copepodid and adult stages in almost any given species.

Distribution.—This species is widely distributed throughout the Atlantic, Indian

and Pacific Oceans, and has very occasionally been taken in the Antarctic Ocean. For details of this distribution I refer the reader to the account given by Steuer (1932, pp. 44 and 55, Charts 1 and 2).

Genus *Gaussia* Wolfenden.

Gaussia, Wolfenden, 1905, p. .

Gaussia princeps (T. Scott).

Pleuromma princeps, T. Scott, 1894, p. 42, pl. iii, figs. 8–12.
Gaussia melanotica, Wolfenden, 1905, p. 5, pl. ii, figs. 1–5 (in a revised version of this paper he changed the name to *G. scotti*).
Metridia atra, Esterly, 1906, p. 70, pl. ix, figs. 15, 16, pl. xi, figs. 39, 40, pl. xiii, fig. 78, pl. xiv, fig. 95.
Gaussia scotti, Wolfenden, 1911, p. 290, pl. xxxiii, figs. 3–11.
Gaussia princeps, Sewell, 1932, p. 270, pls. v and vi, text-figs. 92 and 93 *a–f*.

Occurrence :

Sta. 95, Central part of Arabian Sea, 984–430 m., 1 female, 2 males.

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 male.

Descriptive Notes.—These specimens agree closely with those taken by the "Investigator" in the Bay of Bengal. The female is without the usual black cementing substance on the genital segment and presumably therefore was not breeding. In the males, as in the examples from the Bay of Bengal (*vide* Sewell, 1932, p. 275), the left 5th leg is clearly divided into four segments, and the terminal one bears three unequal spines on the inner border, thus agreeing with Esterly's account of *Metridia atra*. Unfortunately in my earlier account I inadvertently transposed the two legs ; my description of the right leg thus refers to the left and *vice versa*.

Distribution.—In the Atlantic Ocean from lat. 20° N., in the tropical region, and as far as lat. 23° S., between 1500 and 3000 metres (Wolfenden). In the Indian Ocean from the central area of the Arabian Sea (present record) and the Bay of Bengal (Sewell). In the Pacific Ocean from the San Diego region of the coast of California (Esterly). In the two latter oceans it occurs in less deep water, ranging from 366 metres to 869 metres.

Family Lucicutiidæ.

Genus *Lucicutia* Giesbrecht.

Lucicutia, Giesbrecht, 1892, pp. 62, 358 ; Giesbrecht and Schmeil, 1898, p. 110.

Lucicutia bicornuta Wolfenden.

Lucicutia bicornuta, Wolfenden, 1905, p. 24, pl. ii, fig. 6 ; A. Scott, 1909, p. 126, pl. xxxix, figs. 1–11 ; Sars, 1925, p. 214, pl. lviii, figs. 1–3.
Lucicutia aurita Sars, 1905, p. 8 ; 1907, p. 3.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 1500–0 m. vertical, 1 female, 1 male.

Distribution.—In the North Atlantic Ocean (Sars), in the South Atlantic Ocean (Wolfenden), in the Arabian Sea (present record), the Bay of Bengal (Sewell) and the Malay Archipelago (A. Scott).

Lucicutia challengeri Sewell.

(?) *Leuckartia flavicornis* (*non* Claus), Brady, 1883, p. 50, pl. xv, figs. 1–6, 16.
Lucicutia challengeri, Sewell, 1932, p. 290, text-fig. 95, *a–j*.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 12 specimens ; 1500–0 m., 11 specimens.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 8 females, 1 male.

Sta. 76, Gulf of Oman, 1500–0 m., 61 females, 12 males, 12 juv.

Sta. 96, Central part of Arabian Sea, 645–400 m., 2 females, 1 juv.

Sta. 172, Central part of Arabian Sea, 850–0 m., 32 specimens; 2091–0 m., 1 male.

Distribution.—This species has now been recorded from the Arabian Sea and Gulf of Oman (present records), the Bay of Bengal and Laccadive Sea (Sewell), and the Pacific and Atlantic Oceans (Brady, as *L. flavicornis*).

Lucicutia flavicornis (Claus).

Leuckartia flavicornis, Giesbrecht, 1892, p. 358, pl. v, fig. 4, pl. xix, figs. 2, 3, 15–17, 21, 23, 29, 38, pl. xxxviii, figs. 38, 40.
Lucicutia flavicornis, Esterly, 1905, p. 180, fig. 36, *a–c* ; Farran, 1926, p. 274, pl. ix, figs. 1–3.

Occurrence.—Sta. 61, Northern area of Arabian Sea, surface, 1 female.

Descriptive Notes.—Farran (*loc. cit.*) has called attention to the existence of two very closely allied species, *L. flavicornis* (Giesbrecht) and *L. gemmina* Farran, which differ in size and in certain small differences of structure. The true *L. flavicornis* is the smaller of the two and, according to Farran, has a length measurement of 1·47–1·58 mm. in the female and 1·44–1·56 mm. in the male. The present specimen has a length measurement of 1·466 mm.

Distribution.—This species appears to be widely distributed throughout all three great Oceans. In the Pacific it has been recorded from San Francisco Bay and the San Diego region of the coast of California (Esterly), between lats. 12° N. and 3° S. and longs. 87° to 128° W. (Giesbrecht), off New Zealand, and on the Australian Barrier Reefs (Farran) and in the Malay Archipelago (A. Scott). In the Indian Ocean from the coast of Southern Burma and Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present record), the Red Sea (A. Scott), and the Agulhas Current (Cleve). In the Atlantic Ocean from the west of Cape Colony (Cleve), the Gulf of Guinea (T. Scott), in the tropical Atlantic (Giesbrecht, Wolfenden), the Antilles and Florida currents (Cleve), in the Sargasso Sea (Cleve), the temperate Atlantic (Sars, Rose), off the Canary Islands (Thompson) and the Azores (Cleve), in the Bay of Biscay (Farran), off the west coast of Ireland (Farran, Pearson), and in the Mediterranean Sea (Claus, Steuer, Pesta).

Lucicutia magna Wolfenden.

Lucicutia magna, Wolfenden, 1904, p. 121, pl. ix, figs. 35, 35*a* ; 1911, p. 316, fig. 59 ; Wilson, 1932, p. 130, fig. 88, *a–c*.
Lucicutia atlantica, Wolfenden, 1904, p. 121 ; Farran, 1905, p. 44, pl. xiii, figs. 5–10 ; Sars, 1925, p. 217, pl. lix, figs. 1–5.

Occurrence.—Sta. 145 C, Maldive area, 500–0 m. vertical, 1 female.

Distribution.—Originally described from the Faroe Channel (Wolfenden), this species has since been obtained from the west coast of Ireland and the Bay of Biscay (Farran), the western part of the Mediterranean Sea and off the Azores (Sars), the Woods Hole region of the coast of North America (Wilson), the South Atlantic Ocean and the Antarctic Ocean (Wolfenden), the Maldive area (present record), the Pacific Ocean (Sars), and the Pacific region of the Antarctic Ocean (Farran).

Family Heterorhabdidæ.

Genus *Heterorhabdus* Giesbrecht.

Heterorhabdus, Giesbrecht, 1892, p. 372 ; Giesbrecht and Schmeil, 1898, p. 113.

Heterorhabdus abyssalis (Giesbrecht). (Text-fig. 46, a–h.)

Heterochæta abyssalis, Giesbrecht, 1892, p. 373, pl. xix, fig. 4, pl. xx, figs. 29, 30.
Heterorhabdus abyssalis, Farran, 1905, p. 45 ; 1926, p. 280.

Occurrence :

Sta. 96, Northern area of Arabian Sea, 645–400 m., 4 females, 1 male.
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female.
Sta. 145 D, Maldive area, 500–0 m. vertical, 1 male.
Sta. 172, Central area of Arabian Sea, 400–0 m., 2 females ; 850–0 m., 2 females.

Descriptive Notes.—♀. These examples appear to be considerably larger than specimens from the Atlantic Ocean, and measure from 3·08 to 3·1 mm. in length. Farran's examples from the Bay of Biscay showed a length measurement that ranged from 2·2–2·6 mm. The proportional lengths of the various segments of the body are as follows, and for convenience of reference I have also given these lengths in specimens of *abyssalis* and *norvegicus* from the Irish coast, which were very kindly sent me by Mr. G. P. Farran.

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.	
abyssalis (Indian Ocean)	302	116	88	88	114	122	44	38	27	70	= 1000.
abyssalis (Irish coast)	318	104	79	79	116	132	43	34	21	74	= 1000.
norvegicus (Irish coast)	323	103	76	76	121	130	45	35	20	71	= 1000.

There are thus slight differences in the proportional lengths of certain of the segments in the Indian form and that from the Irish coast, but these are not sufficiently marked to serve as valid grounds for distinguishing the two forms.

The forehead is rounded and there is no trace of any spine, such as is found in *spinifrons*. A well-marked cervical groove is present. The posterior thoracic margin is rounded. In the abdomen the genital segment is constricted in the posterior third of its length. The genital aperture closely resembles that of *norvegicus* and *austrinus*, but the aperture is further forward than in this latter species. The genital segment and the next two following (Text-fig. 46, *a*) are fringed along their posterior margins with small

spinules. The furcal rami are of unequal length and the 2nd seta on the left ramus is thickened and greatly increased in length.

The 1st antenna over-reaches the furcal rami by about the last three segments. The proportional lengths of the various segments are as follows, and for reference I also give the lengths in a specimen of *abyssalis* from the Irish coast and of *norvegicus* from the same region:

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
abyssalis (Irish coast)	87	12	10	10	12	18	18	18	19	25	32	31	53	57
abyssalis (Indian Ocean)	82	13	12	10	11	15	19	16	17	22	31	28	50	56
norvegicus (Irish coast)	80	12	10	10	11	13	16	15	17	19	28	27	50	56

Segment	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
abyssalis (Irish coast)	62	64	65	62	67	55	50	54	52	51	16 = 1000.
abyssalis (Indian Ocean)	60	63	65	65	72	58	53	57	56	51	18 = 1000.
norvegicus (Irish coast)	60	64	65	65	72	63	54	60	60	53	20 = 1000.

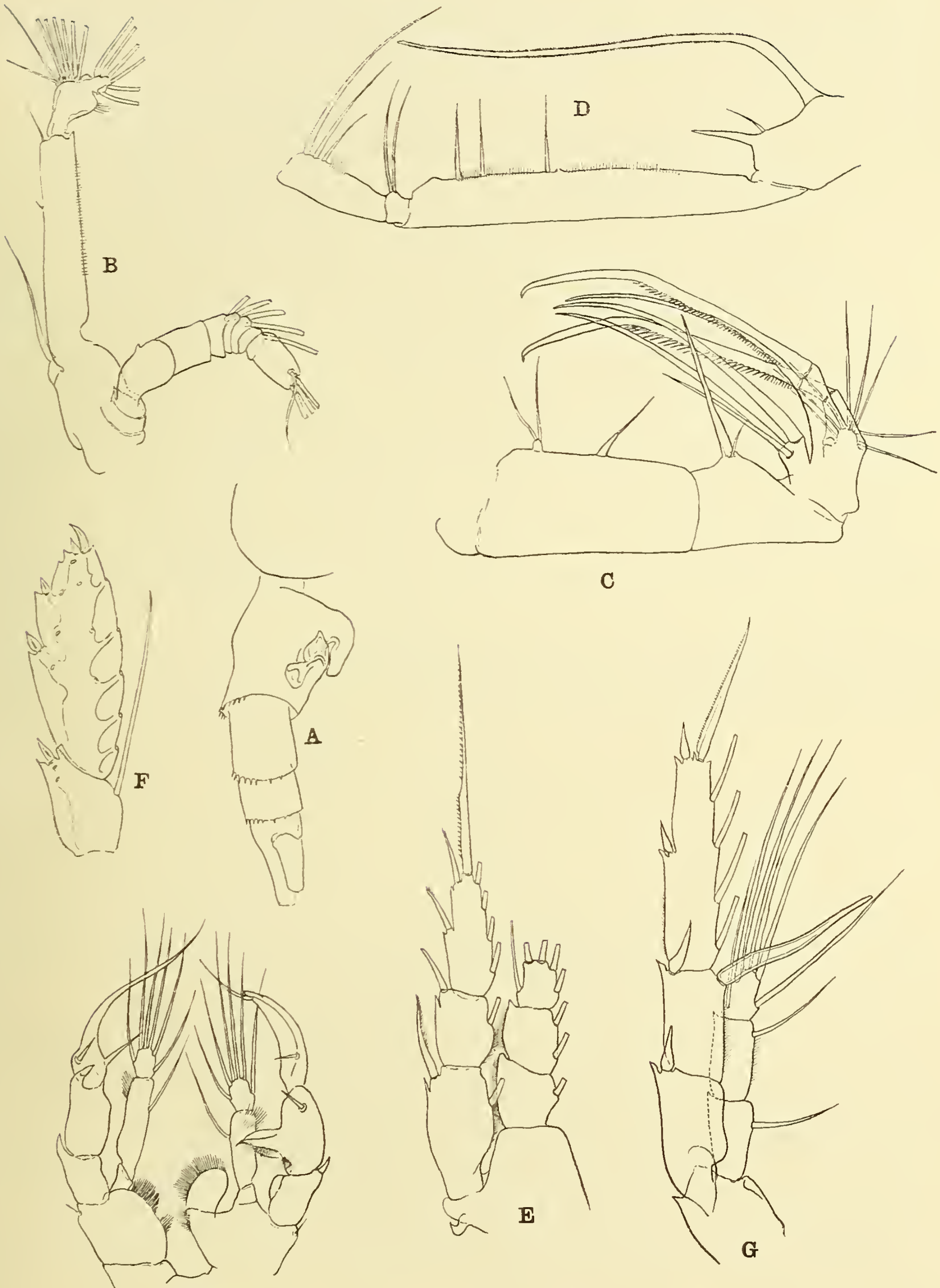
It seems clear that these proportional lengths exhibit slight differences in the three forms, and that these differences are progressive as we pass from the smallest form, *abyssalis* from the Irish coast, through *abyssalis* from the Indian Ocean to *norvegicus* from the Irish coast. Segment 1 decreases in length ; in segments 2 to 5 the differences are slight and appear to be irregular, but from 6 to 16 the length is almost invariably smaller in the larger form ; segment 17 remains the same length in all three forms ; from segment 18 to the end the length of the segment increases as we pass from the smaller to the larger form. These differences are the exact opposite of what I have usually found to occur in growth stages of the same species (*vide* Sewell, 1929, p. 9). In all three forms the joints between segments 8, 9 and 10 appear to be more or less incomplete, so that there can be little or no flexibility in this portion of the appendage. The proximal segments bear long sensory filaments, and two at the distal end of segment 1 and one each on segments 3, 7 and 12 are especially long.

The 2nd antenna and mouth parts (Text-fig. 46, B–D) resemble those of other members of the genus : the 2nd maxilla appears to be identical in all three forms and closely resembles that of *H. austrinus* Giesbrecht.

In the 1st leg (Text-fig. 46, E) the 2nd basal segment bears on its outer margin a stout curved process, that is in all probability a modified seta ; it projects backwards, and is thus best seen when the animal is viewed from the side. So far as I am aware, no such process has been described in any other member of the genus ; Giesbrecht (1892, pl. xx, fig. 24) has figured it in *H. spinifrons*, but I can find no reference to it in the text : an exactly similar process is present in *H. norvegicus*. The inner seta arising from the 2nd segment of the exopod is somewhat stouter than those arising from segment 3 ; this condition is also present in *H. norvegicus*.

In the 3rd leg (Text-fig. 46, F) the last segment of the exopod, is oval and very closely resembles that of *H. spinifrons*.

In the 5th leg (Text-fig. 46, G) the 1st segment of the exopod is devoid of any inner seta, and the setæ arising from 1st and 2nd segments of the endopod are considerably more delicate than those of the 3rd segment ; the same difference is present in *H. norvegicus*. The end spine in the Indian form is somewhat longer in proportion to the length of



TEXT-FIG. 46.—*Heterorhabdus abyssalis* (Giesbrecht). A, Abdomen, from the right side, ♀. B, 2nd antenna, ♀. C, 2nd maxilla, ♀. D, Maxilliped, ♀. E, 1st leg, ♀. F, 3rd leg, exopod, ♀. G, 5th leg, ♀. H, 5th pair of legs, ♂.

the 3rd segment of the exopod than in either *H. abyssalis* from the Irish coast or in *H. norvegicus* ; the proportional lengths in the three forms are as follows :

Species.	Proportional lengths of— Exopod 3.	Endspine.
abyssalis (Indian Ocean)	100	60
abyssalis (Irish coast)	100	50
norvegicus (Irish coast)	100	47

♂. Total length 2·85 mm.

The proportional lengths of the various segments of the body are as follows, and for comparison I have given the corresponding lengths of the segments in specimens of *H. norvegicus* and *H. abyssalis* from the Irish coast :

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
abyssalis (Irish coast)	309	112	86	90	112	66	54	46	40	20	65 = 1000.
abyssalis (Indian Ocean)	312	108	86	86	108	65	53	51	40	25	63 = 1000.
norvegicus (Irish coast)	312	104	89	89	104	62	55	47	39	26	73 = 1000.

There is thus little difference between these three forms.

In the grasping antenna the proportional lengths of the segments forming the hinge-joint are almost identical, as is shown below :

	abyssalis. Irish coast.	*abyssalis.* Indian ocean.	*norvegicus.* Irish coast.
Segment 17	28	27	26
,, 18	13	13	13
,, 19–21	59	60	61

I have been entirely unable to detect any difference in the mouth parts and swimming legs of these three forms, and it seems clear that Farran is correct in thinking that *abyssalis* and *norvegicus* are races or forms of the same species.

Remarks.—It is extremely difficult, if not impossible, in the present state of our knowledge, to discriminate between several " species " of *Heterorhabdus*. Farran (1926, p. 281) remarks : " It is not perfectly clear whether these specimens (of what he considers to be *norvegicus* from the Bay of Biscay) are true *H. norvegicus* or a closely-allied southern form, perhaps *H. profundus*." Again, in 1929 (p. 265), in his Report on the Copepoda of the " Terra Nova " expedition, he states that in examples of what he took to be *austrinus* " the females scarcely differ, except in their slightly larger size, from the North Atlantic species which I have referred to *H. norvegicus*, but the more slender inner edge spine on the second joint of the exopodite of the 5th foot in *H. austrinus* seems in most cases to be a diagnostic character." It would be out of place to attempt here to elucidate this problem, but from the above it would seem probable that *norvegicus*, as understood by Farran, and *abyssalis* are size groups of one and the same species : and it is interesting to note that Farran also found similar size groups in *H. austrinus*.

Distribution.—The form *norvegicus* appears to be confined to the Arctic and North Atlantic Oceans: it has been recorded from the Polar Basin (Sars), the Arctic Ocean (Mrazek, Damas and Koefoed, van Höffen), the Norwegian coast (Boeck, Sars), the Faroe Channel (Norman, Wolfenden), Greenland (Norman, Jespersen), the North Atlantic (Sars, Lysholm and Nordgaard), the Irish coast (Farran), the Bay of Biscay (Farran), the Gulf of Maine (Bigelow) and the region off Georges Bank (Wilson). The vertical range appears to be from 100–2000 metres, but the depth seems to differ on the two sides of the Atlantic, for on the eastern side, off Ireland and in the Bay of Biscay the range is given by Farran as 350 to 732 metres, in the central region it occurs from 150 to 1500 metres and is common at 1000 metres, whereas off Greenland it may occur as deep as 2000 metres.

The form *abyssalis* appears to be an Atlantic and Indian Ocean form. It has been recorded from the North Atlantic (van Breemen), the Irish coast (Farran), the Bay of Biscay (Farran), west of Cape Verde Islands (Wolfenden), east of Cape Colony (Cleve), the Arabian Sea and Maldive area (present records), and the Arabian Sea and Gulf of Aden (Thompson and A. Scott). The depth at which this form is found seems to be rather less deep than that of *norvegicus* in the Atlantic Ocean; it occurs off the Irish coast at about 220 metres, and in the Bay of Biscay its optimum lies between 183 and 366 metres.

Off the east coast of Cape Colony below the Agulhas Current it was taken between 530 and 900 metres, and in the Arabian Sea it lies at depths ranging from 400–1500 metres.

Sars (1925, p. 226) has recorded that *H. norvegicus* has been taken in the Pacific Ocean. I am inclined to doubt this, and think that it is more likely that he was actually dealing with *H. abyssalis*: unfortunately he does not give the size of these specimens.

Heterorhabdus spinifrons (Claus).

Heterochæta spinifrons, Giesbrecht, 1892, p. 372, pl. xx, figs. 1, 3, 11, 16, 19, 31, pl. xxxix, figs. 42, 43, 51, 52, 54.

Heterorhabdus spinifrons, Esterly, 1905, p. 183, fig. 37, *a*, *b*; van Breemen, 1908, p. 119, fig. 137, *a–c*; Sars, 1925, p. 227, pl. lxii, figs. 9–12.

Occurrence:

Sta. 96, Northern area of Arabian Sea, 645–400 m., 2 males.

Sta. 172, Central part of Arabian Sea, 200–0 m., 1 male; 400–0 m., 1 female; 850–0 m., 1 male.

Sta. 186, Gulf of Aden, 575–0 m., 4 females, 1 male.

♀. The total length of the present examples is 3·433 mm. The forehead shows the characteristic spinous projection on the rostral papilla. In the abdomen the genital swelling is well marked, and on the anterior border are a pair of unequal small rounded prominences, that on the right side being considerably the larger.

The 1st antenna overreaches the tip of the furcal rami by about the last three or four segments. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	79	10	10	10	10	12	17	15	18	22	32	28	57	60	64	66	67	63

Segment	19.	20.	21.	22.	23.	24–25.	
	72	59	52	58	53	66	= 1000.

There are four very long sensory filaments arising from the 1st segment and one each from the 2nd, 3rd, 4th and 7th segments. The 1st segment bears three pores, one each near the base of origin of the corresponding "trithek."

The 2nd antenna resembles that of other members of the genus.

In the mandible the two rami of the palp are of equal length: the biting ramus resembles that of *H. papilligera.*

In the 1st maxilla the 2nd inner lobe bears 1 seta and the 3rd has none; the 2nd basal segment and endopod are greatly reduced and bear 1 and 3 small setæ respectively; the exopod is well developed and carries 5 setæ, and the outer lobe also bears 5.

The 2nd maxilla is armed on the 6th lobe with a stout spine, the proximal two-thirds of which is fringed with teeth. From the 5th lobe two unequal stout spines arise, the stronger being fringed with very small spinules. The 4th lobe bears two long stout spines and one short one, this latter being only about one-fifth the length of the other two. The 3rd lobe bears a stout spine, that is half the length of those arising from the 5th lobe, and a small delicate seta.

In the maxilliped the 1st basal segment bears the characteristic long filament on its anterior margin, and at the distal anterior angle is produced in a pointed process that extends about one-third the length of the 2nd basal segment.

The 1st leg bears on the outer border of the 2nd basal segment a stout process that is directed backwards; this is figured by Giesbrecht (1892, pl. xx, fig. 24).

The 2nd, 3rd and 4th legs resemble those of the preceding species, *H. abyssalis.*

In the 5th leg the 1st segment of the exopod is devoid of any inner seta, and the setæ arising from the 1st and 2nd segments of the endopod are much more delicate than those on segment 3. The inner spine on the 2nd segment of the exopod is stout, and approximately equal in length to the 3rd segment. The terminal spine on the 3rd segment is about one-third the length of the segment.

Distribution.—In the Atlantic Ocean this species has been taken in the North Atlantic (Sars), the Gulf of Maine (Bigelow), the Woods Hole region (Wilson), the west coast of Ireland (Farran, Pearson), the Bay of Biscay (Farran), the Mediterranean Sea (Thompson, Thompson and A. Scott, Pesta), equatorial and south Atlantic (Wolfenden), the Gulf of Guinea (T. Scott) and west of Cape Colony (Cleve). In the Indian Ocean off the east coast of Cape Colony (Cleve), the Arabian Sea (Thompson and A. Scott, present records), the Gulf of Aden (present records) and the Laccadive Sea (Thompson and A. Scott, Sewell). In the Pacific Ocean from the Malay Archipelago (A. Scott), the Australian Barrier Reefs (Farran), off New Zealand (Farran), both east and west regions of the Pacific Ocean (Giesbrecht) and off the San Diego region of the coast of California (Esterly).

The depth distribution has a wide range; off Ireland it is said to extend from 0 to 1770 fathoms (3237 metres), but in the Bay of Biscay Farran shows it as extending from 50 fathoms (91 metres) to 500 fathoms (914 metres), with an optimum between 100 and 150 fathoms (183 to 272 metres). Off Cape Colony it was taken at 250 to 530 metres, in the Arabian Sea between 400 and 850 metres, in the Laccadive Sea between 366 and 1280 metres, and in the central Pacific Ocean and on the Barrier Reef in 500 metres, but off New Zealand in only 0–50 metres.

Genus *Heterostylites* Sars.

Heterostylites, Sars, 1920.

Heterostylites longicornis (Giesbrecht).

Heterochæta longicornis, Giesbrecht, 1892, p. 373, pl. xx, figs. 14, 21, 25, 26, pl. xxxix, fig. 44.
Heterostylites longicornis, Sars, 1925, p. 238, pl. lxvii, figs. 1–16.

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 female, 1 male.

Sta. 131 D. Southern area of Arabian Sea, 500–0 m.. 1 female.

Distribution.—In the Atlantic Ocean from the Faroe Channel (Wolfenden), the west coast of Ireland (Farran), the Bay of Biscay (Farran), the North Atlantic (Sars), the Gulf of Maine (Bigelow), the Woods Hole region (Wilson), the South Atlantic (Wolfenden), the Antarctic Ocean (Wolfenden). In the Indian Ocean from the Arabian Sea and Gulf of Oman (present records) and the Bay of Bengal (Sewell). In the Pacific Ocean from the Malay Archipelago (A. Scott) and the San Diego region of the coast of California (Esterly).

Genus *Hemirhabdus* Wolfenden.

Hemirhabdus, Wolfenden, 1911, p. 308.

Hemirhabdus grimaldii (Richard).

Heterochæta grimaldii, Richard, 1893, p. 151.
Heterorhabdus grimaldii, Wolfenden, 1905, p. 10, pl. iv, figs. 3–5.
Hemirhabdus grimaldii, Wolfenden, 1911, p. 309, text-fig. 56 ; Sars, 1925, p. 230, pl. lxiii, figs. 1–15 ; Sewell, 1932, p. 304, text-fig. 100, *a–f*.

Occurrence :

Sta. 131 D, Southern area of Arabian Sea, 1500 m., 1 male.

Sta. 172, Central area of Arabian Sea, 2091–0 m., 1 female.

Distribution.—This fine species has now been recorded from Greenland to the south of Davis Strait (Jespersen), off the west coast of Ireland (Farran), in the Bay of Biscay (Farran, Sars), south of the Canary Islands (Sars), near the Cape Verde Islands (Wolfenden), in the Arabian Sea (present records), in the Bay of Bengal (Sewell) and, according to Sars, in the Pacific Ocean.

Hemirhabdus truncatus (A. Scott).

Mesorhabdus truncatus, A. Scott, 1909, p. 132, pl. xxxix, figs. 12–21.
? *Hemirhabdus latus*, Sars, 1925, p. 232, pl. lxiv, figs. 1–16.
Hemirhabdus truncatus, Sewell, 1932, p. 306, text-fig. 101, *a–j*.

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 1 juv.

Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

Descriptive Notes.—This single adult specimen agrees exactly with the example previously recorded by me from the Laccadive Sea, except that it is considerably larger in size. The total length is 9·667 mm., instead of only 7·44 mm. ; but the proportions of the body and the relative length of the abdomen are the same, the latter being contained 2·62 times in the cephalothorax.

Distribution.—This species is now known from the Malay Archipelago (A. Scott), the Laccadive Sea (Sewell) and the Arabian Sea (present record); and, if I am right in thinking that *Hemirhabdus latus* is a synonym, it also occurs in the Pacific and Atlantic Oceans (Sars).

Genus *Mesorhabdus* Sars.

Mesorhabdus, Sars, 1905*b*, p. 9.

Mesorhabdus angustus Sars. (Text-fig. 47, a–g.)

Mesorhabdus angustus, Sars, 1925, p. 236, pl. lxvi, figs. 14–20.

Occurrence:

Sta. 61 C, Northern part of Arabian Sea, 1500–0 m., 1 female.

Sta. 76, Gulf of Oman, 600–0 m., 1 female, 1 male, 2 juv.

Descriptive Notes.—♀. Total length, 7·25 mm.

The proportional lengths of the cephalothorax and abdomen are as 65 to 35. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
339	97	68	63	82	102	54	45	57	93 = 1000.

The forehead is rounded. The base of the rostral papilla is produced in a low rounded prominence that bears two delicate filaments. A well-marked cervical groove runs across the dorsal aspect of the cephalon. The 4th and 5th thoracic segments are fused and the posterior thoracic margin is truncated. The genital segment is equal in length to the two following segments; the genital prominence is not much produced. The furcal rami are markedly unequal, and the 2nd seta on the left ramus is much thickened and of great length, being about twice the length of the whole animal.

The angle of the posterior thoracic margin is occupied by a compact mass of highly refractile gland cells that open on the external surface by a number of orifices. A number of dermal glands are scattered over the dorsal and lateral aspects of the segments of both regions of the body, and a small but compact gland is situated in the base of each furcal ramus. A similar gland is present in the proximal part of the 1st basal segment of the 2nd to 4th legs.

The 1st antenna over-reaches the tip of the furca by the last six segments.

The proportional lengths of the segments are as follows:

Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
68	16	22	24	26	25	25	21	21	24	29	33	48	48	55	62	66	63

19.	20.	21.	22.	23.	24.	25.
74	59	46	46	46	41	12 = 1000.

The sensory filaments on the basal segments are long, as in *Heterorhabdus spinifrons*.

In the 2nd antenna the 1st basal segment is produced in a rounded lobe at its posterior and inner angle; the exopod reaches only about half-way along the 1st segment of the endopod.

The mandible resembles that of *M. brevicaudatus*.

In the 1st maxilla the various lobes bear the following number of setæ :

Li. I . .	10 delicate setæ and 1 strong spine.
Li. II . .	1 seta.
Li. III . .	2 setæ.
Basal 2 . .	2 ,,
Endopod .	5 ,,
Exopod . .	5 small and 6 large setæ.
Le. . .	6 large setæ, the most posterior somewhat smaller than the other 5, and 3 small setæ.

Sars (*loc. cit.*, p. 235) states that in *M. brevicaudatus* this appendage resembles that of *Hemirhabdus*, but in all three species of *Mesorhabdus* the 1st inner or biting lobe is characterized by the presence of a single, long and powerful spine, the remaining setæ being delicate ; in *Hemirhabdus* no such spine is present.

The 2nd maxilla (Text-fig. 47, B) has the same general shape as in *M. brevicaudatus*, but the 3rd and 4th lobes each bear only 2 setæ, whereas Sars figures 3 setæ in both *brevicaudatus* and *gracilis*.

The maxilliped resembles that of other members of the genus.

In the swimming legs the number of setæ on the segments of the endopod are as follows :

P 1.	P 2.	P 3.	P 4.	P 5.
1, 2, 5 .	1, 2, 8 .	1, 2, 8 .	1, 2, 7 .	1, 1, 6

In the 1st leg (Text-fig. 47, C) the 2nd basal segment carries a stout flagellum-like process near the outer distal angle ; this process is directed backwards, and very closely resembles that present in *Heterorhabdus spinifrons* and *H. abyssalis*. The rami very closely resemble those of *Disseta palumboi*, but the distal outer angles of all three segments of the endopod are produced in bluntly rounded lobes.

The 2nd–4th legs resemble those of *Disseta palumboi*, except as regards the much greater development of the epidermal glands ; the 2nd and 3rd segments of the exopod are crowded with glands, that open by numerous pores, as shown in Text-fig. 47, D–F. A gland is present in the 1st basal segment of these legs.

The 5th leg agrees with the figure given by Sars.

Associated with this female was a single adult male, that I have no doubt is the hitherto unknown male of this species.

♂. Total length, 6·717 mm.

The proportional lengths of the anterior and posterior regions of the body are as 66 to 34. The proportional lengths of the various segments are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
356	94	67	62	84	44	52	57	50	50	84 = 1000.

The left 1st antenna is modified into a grasping organ that very closely resembles that of *Heterorhabdus spinifrons* and *H. abyssalis*, even to the proportional lengths of the two segments preceding and following the hinge.

Text-fig. 47.—*Mesorhabdus angustus* Sars, ♂. A, Lateral view. B, 2nd maxilla. C, 1st leg. D, Exopods 2 and 3 of 2nd leg. E, Exopods 2 and 3 of 3rd leg. F, Exopods 2 and 3 of 4th leg. G, 5th pair of legs.

Species.	Segment 17.	Segment 18.	Segments 19–21.	Segments 22–23.
Heterorhabdus				
spinifrons	21	8	39	32
abyssalis	17	9	39	35
Mesorhabdus				
angustus	19	10	39	32

The 2nd antenna and mouth-parts resemble those of the female.

The swimming legs also resemble those of the female.

The 5th pair of legs (Text-fig. 47, G) are of the same general type as in *Heterorhabdus*. In the right leg the 2nd basal segment is produced in a large oval flap, that bears a tuft of hairs at its distal extremity. Both rami are three-jointed. The 1st segment of the exopod bears a stout marginal spine. The 2nd segment is produced inwards in a stout pointed process at its proximal end and bears a marginal spine distally. The 3rd segment bears a spine about the middle of its length, and terminally carries a long spine, as long as the segment itself. The 1st segment of the endopod is devoid of an inner seta, the 2nd segment bears one and the 3rd segment 6 long setæ. In the left leg the 2nd basal segment has a convex inner margin that is fringed with hairs in its distal two-thirds, and bears a delicate spine at its distal outer angle. The 1st segment of the exopod is produced at its distal outer angle and carries a stout spine. The 2nd segment is broadly oval in shape, and bears a spine at about the junction of the middle and distal thirds of its outer margin. The 3rd segment is long and tapers to a point: it bears a long spine, equal to half the length of the segment, close to the base, and a shorter stouter spine at about one-sixth of the length; about the middle of the outer margin there is a small delicate seta. The segments of the endopod on the right leg bear 0, 1, 6 setæ, and of the left 0, 0, 6 setæ.

Distribution.—This species has now been recorded from the North Atlantic Ocean (Sars), the Arabian Sea (present record) and the Laccadive Sea (Sewell).

Genus *Disseta* Giesbrecht.

Disseta, Giesbrecht, 1892, p. 369; Giesbrecht and Schmeil, 1898, p. 112.

Disseta palumboi Giesbrecht. (Text-fig. 48, A–I.)

Disseta palumboi, Giesbrecht, 1892, p. 369, pl. xxix, figs. 2, 8, 14, 19, 23–25, 27, pl. xxxviii, fig. 44; A. Scott, 1909, p. 133, pl. xli, figs. 11–21; Sars, 1925, p. 221, pl. lx, figs. 1–14; Rose, M., 1929, p. 34, pl. ii, fig. 4; Sewell, 1932, p. 309, text-figs. 102, 103, *a–d*.
Heterorhabdus grandis, Wolfenden, 1904, p. 120, pl. ix, fig. 36; *idem*, 1905, p. 8, pl. iv, figs. 7, 8; van Breemen, 1908, pp. 126, 227, figs. 145, 243.
Disseta atlantica, Wolfenden, 1911, p. 313.
Disseta grandis (♀ only), Esterly, 1906, p. 72, pl. ix, fig. 21, pl. xi, figs. 45, 46, pl. xiii, fig. 69, pl. xiv, figs. 88, 94.
Disseta sp., Esterly, 1911, p. 331, pl. xxvii, figs. 40, 41, pl. xxx, figs. 76, 80, pl. xxxi, fig. 100, pl. xxxii, figs. 107, 108.

Occurrence:

Sta. 76, Gulf of Oman, 600–0 m., 1 female.

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female, 1 juv.

Sta. 131 D, Southern part of Arabian Sea, 1500–0 m., 3 females, 5 males.

Sta. 172, Central part of Arabian Sea, 850–0 m., 6 females, 5 males, 7 juv.

Descriptive Notes.—♀. Total length, 7·33–7·45 mm.

The proportional lengths of the anterior and posterior regions of the body are as 67 to 33. The proportional lengths of the various segments of the body are as follows :

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
(1)	275	129	84	92	88	111	63	52	33	73 (67)
(2)	269	136	78	95	85	111	66	58	29	82 (66)

The inequality of the two furcal rami was considerably more marked in the second specimen than in the first, as is shown by the figures given above. In a previous paper I have called attention to the integumentary glands that open by relatively large pores on the surface of the body and on certain of the appendages : in addition to these a gland composed of granular protoplasm is situated in the postero-lateral region of the combined 4th–5th thoracic segment (Text-fig. 47, A). The posterior angle of this segment is bluntly rounded.

The genital segment exhibits a rounded swelling in the dorso-lateral region. The segment is covered with numerous minute needle-like spinules in the posterior two-thirds of its length on the dorsal and lateral aspects. The posterior borders of the abdominal segments are fringed with needle-like spinules, those on the 4th segment being somewhat more coarse than the others.

The 1st antenna overreaches the tip of the furcal rami by 5 segments in one specimen and 5½ segments in the other. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	53	13	16	14	16	17	17	16	15	18	21	25	39	48	55	67	74	80

19.	20.	21.	22.	23.	24.	25.	
76	64	57	56	62	57	24	= 1000.

A comparison of these figures with those given for specimens from the Bay of Bengal (*vide* Sewell, 1932, p. 310) shows little difference. The demarcation between segments 8, 9 and 10 is quite clear, though perhaps not quite so complete as in the rest of the appendage. The 1st segment shows clearly the thickenings of the chitin, to which Giesbrecht drew attention (Text-fig. 47, B).

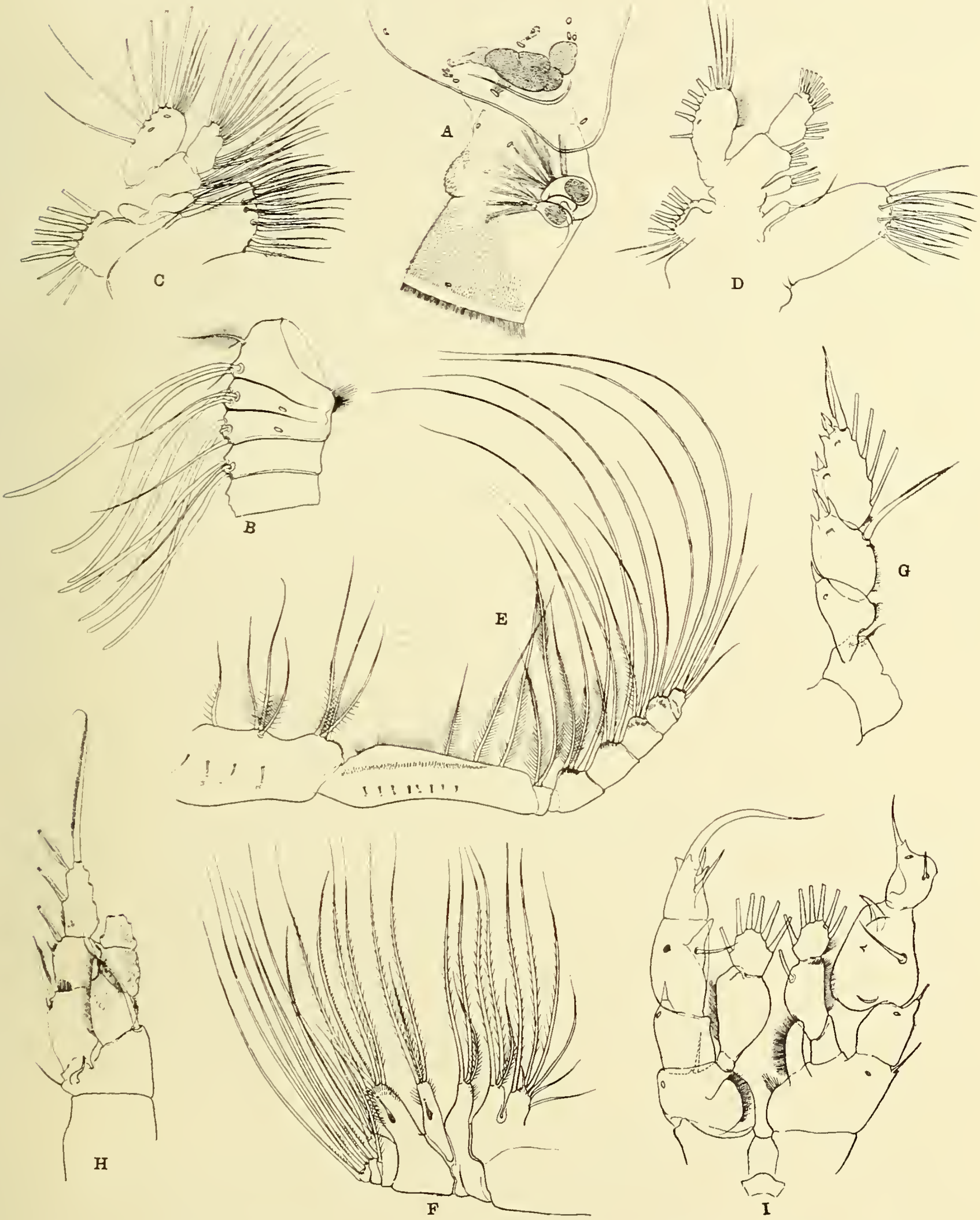
In the 2nd antenna the endopod is slightly longer than the exopod : Giesbrecht (1892, p. 370) states that the two rami are of approximately equal length, but in his figure he shows the endopod as being slightly the longer in the proportion of 42 to 35. In the present specimens they are 45 and 35 or 41 and 34 respectively. In its general structure the present specimens agree exactly with Giesbrecht's figure.

In the mandible the endopod is actually shorter than the exopod or of the same length, but owing to the method of articulation of the two rami, the endopod reaches far beyond the tip of the exopod, as is correctly shown by Giesbrecht (1892, pl. xxix, fig. 14).

In the 1st maxilla (Text-fig. 47, C) the various lobes bear the following number of setæ :

Li. I	14 spines or setæ.
Li. II . . .	1 seta.
Li. III . . .	3 setæ.
Basal 2 . . .	4 setæ.

Endopod . . .	3, 4 and 5 setæ on the three segments.
Exopod . . .	6 large and 5 smaller setæ.
Le. I . . .	3 small and 6 large setæ.



TEXT-FIG. 48.—*Disseta palumboi* Giesbrecht. A, Posterior thoracic margin and genital segment, ♀. B. Proximal three segments of 1st antenna, ♀. C, 1st maxilla, ♀. D, 1st maxilla, ♂. E, Maxilliped, ♀. F, 2nd maxilla, ♀. G, 5th leg, exopod, ♀. H, 1st leg, ♂. I, 5th pair of legs, ♂.

Wolfenden's claim that *D. atlantica* differs from *D. palumboi* in possessing 12 setæ on the endopod instead of 9 is invalid: Giesbrecht (1892, p. 370) gives the numbers of setæ on the three segments of the endopod as 3, 4 and 5 respectively, making 12 in all.

The 2nd maxilla and the maxilliped (Text-fig. 47, E, F) agree exactly with Wolfenden's account of the appendages in *D. atlantica.*

In the 1st leg (Text-fig. 47, H) the 2nd basal segment bears on its posterior aspect a slender delicate process that arises from a slightly swollen base; this structure appears to be identical with the process to which I have already called attention in the genera *Heterorhabdus*, *Hemirhabdus*, *Mesorhabdus*, *Heterostylites*, *Lucicutia*, *Pleuromamma* and *Metridia.*

Accompanying these females were several males.

♂. Total length 6·667–7·00 mm.

The proportional lengths of the anterior and posterior regions of the body are as 65 to 35. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
258	128	81	97	89	52	60	65	58	34	78 (58)

As Esterly (1911, p. 331) in his account of *Disseta* sp. from the San Diego Region has pointed out, the middle segment of the abdomen is the longest.

The 1st antenna is about the length of the body, and the proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Right	53	16	17	16	17	17	17	17	17	17	22	24	42	48	50	58	66	77
Left	76		26	26	26	26	26	20	20	20	20	22	38	50	66	80	74	50

Segment	19–20.		21.	22.	23.	24.	25.	
Right	73	62	58	58	67	62	29	= 1000.
Left	107			129		68	30	= 1000.

The portion of the left antenna beyond the knee-joint is composed of four "segments," segments 19–20 and 21–23 respectively being fused. This agrees with Wolfenden's account of the grasping antenna in *D. atlantica*, and if the proportional lengths of these last five segments that he gives are recalculated, so as to correspond to the figures given above, the proportional lengths become 47, 112, 118, 59, 35, thus showing a very fair degree of agreement. Esterly also in his account of the form that he described under the name *D. grandis* states that the terminal portion of the grasping antenna is composed of four segments, but unfortunately he gives no measurements. On the other hand Rose (1929, pl. ii, fig. 4, L) shows seven segments in the terminal portion of the antenna in the specimen that he examined.

The 2nd antenna agrees with that of the female.

In the 1st maxilla (Text-fig. 47, D) the various lobes possess the same number of setæ as in the female, but a comparison of the two appendages shows that there is a slight difference in the character of the 1st inner lobe, which is not so strongly developed in the male as in the female.

The 2nd maxilla and maxilliped appear to agree with the female.

The first four pairs of legs resemble those of the female.

The 5th feet (Text-fig. 47, I) of the present specimens agree closely with the description and figures given by Wolfenden (1905, pl. iv, figs. 7, 8) for his *Heterorhabdus grandis*, by A. Scott (1909, pl. xli, fig. 21) and Rose (1929, pl. ii, fig. 4, p. 5) for *Disseta palumboi*, as well as with the description by Wolfenden (1911, p. 314) of the same appendage in *Disseta atlantica*, and Esterly's account and figure (1911, pl. xxxii, figs. 107, 108) of the appendage in his *Disseta* sp., and there can be little or no doubt that all these forms are synonymous. On the other hand the form of this appendage in Esterly's *Disseta grandis* (1906, pl. xiv, figs. 88, 94) and in my *D. palumboi* (1932, text-fig. 103, *c*, *d*) show certain differences, especially as regards the terminal segment of the exopod of the left leg, in which the terminal spine is much shorter.

Remarks.—Farran (1906, p. 67) remarks, " Dr. Wolfenden's figures of *Heterorhabdus grandis* furnish unmistakable proof of the identity of that species with *Disseta palumboi*," but more recently he appears to have had some doubts on the subject, for he writes (1926, p. 279), " In 1911 Wolfenden redescribed, as it seems, the Atlantic form, which he had previously named *grandis*, as *D. atlantica* from specimens taken by the 'Gauss' and pointed out some characters in which it differed from Giesbrecht's Pacific species." As I have mentioned above, some of Wolfenden's supposed differences are invalid, and I can see no grounds for separating the various females into Pacific and Atlantic forms or species. In the case of the males, however, I am not so certain : the form that Esterly (1906) described as the male of *D. grandis* and that I recorded (1932) from the Bay of Bengal does present certain slight differences, and it is possible that this is either a different species or possibly only an Indo-Pacific variety of the Atlantic form. The form that Esterly (1911) recorded under the name *D. maxima* is, in my opinion, a good species, and so also is Brady's *Leuckartia scopularis* (1883, p. 51, pl. xiv, figs. 1–5), which, as A. Scott (1909, p. 134) has pointed out, is in reality a *Disseta*. *Disseta maxima* is known only from the female, which measured 9·4 mm. in length, while *D. scopularis* is known only from the male, which has a length of 9·75 mm. : both were taken in the Pacific region, and it is possible that they are the two sexes of one species.

Distribution.—*D. palumboi* appears to be a very widely distributed species, and if I am correct in my conclusion, it has been recorded from the west coast of Ireland (Wolfenden, Farran), the Bay of Biscay (Farran), the North Atlantic (Sars, Rose), the South Atlantic (Wolfenden), the Arabian Sea and Gulf of Oman (present records), the Bay of Bengal and Laccadive Sea (Sewell), the Malay Archipelago (A. Scott), the western Pacific Ocean (Giesbrecht), and the San Diego region of the Californian coast (Esterly).

Family Augaptilidæ.

Genus *Haloptilus* Giesbrecht.

Haloptilus, Giesbrecht, 1892, p. 384 ; Giesbrecht and Schmeil, 1898, p. 117.

In this genus the 2nd maxilla exhibits a considerable degree of variation in the number of setæ that arise from the different lobes in different species, as is shown in the following table :

Species.	Number of setæ arising from the lobes of the 2nd maxilla.					
	1.	2.	3.	4.	5.	6.
major Wolfenden	3	3	3	3	3	4
chierchiæ Giesbr. } ? *fons* Farran	3	3	3	2	2	3
acutifrons Giesbr. } *mucronatus* (Claus)	3	2	2	2	2	4
ornatus (Giesbr.) } *validus* Sars	3	2	2	2	2	3
tenuis Farran	3	1	2	2	2	7 (?)

A comparison of the mouth-parts in the two sexes of several species in the genus reveals that there is a slight, though quite distinct, tendency for those of the male to be reduced. Giesbrecht (1892, p. 395) has already pointed this out, and remarks that the four appendages, mandible, 1st and 2nd maxilla and maxilliped, are in the male similar to those of the female, but are on the whole more feebly developed and are not so strongly armed. This he has noticed especially in *longicornis*, and he further notes that in *ornatus* the spines on the two short hooks of the 1st inner lobe of the 1st maxilla, which have a characteristic thickness in the female, are absent in the male. A comparison of the two sexes of *chierchiæ* reveals that here too there is a quite distinct reduction of the mouth-parts in the male, which is especially noticeable in the biting ramus of the mandible and in the 2nd maxilla.

Haloptilus acutifrons (Giesbrecht).

Hemicalanus acutifrons, Giesbrecht, 1892, p. 384, pl. iii, fig. 11, pl. xxvii, fig. 12, pl. xlii, figs. 12, 20.
Haloptilus acutifrons, Sars, 1901–03, p. 12, pl. lxxxii, fig. 2 ; *idem*, 1925, p. 250, pl. lxxiv, figs. 1–11.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 2000–0 m., 1 female.

Sta. 76, Gulf of Oman, 600–0 m., 1 female.

Distribution.—The Arctic Ocean (Sars, as *H. spinifrons*), the Norwegian Sea (Sars), in Baffin Bay and to the south of Davis Strait (Jespersen), the Irish coast (Farran), the Bay of Biscay (Farran), Mediterranean Sea (Giesbrecht), the North Atlantic Ocean (Sars, Farran), the Atlantic region of the Southern Ocean (T. Scott), the Arabian Sea and Gulf of Oman (present records), the Australian Barrier Reefs (Farran) and off New Zealand (Farran). (For details of the distribution of this species in the North Atlantic Ocean, see Jespersen, 1934, p. 111, fig. 28.)

Haloptilus chierchiæ (Giesbrecht). (Text-fig. 49, a–i.)

Hemicalanus chierchiæ, Giesbrecht, 1892, p. 384, pl. xxvii, figs. 16, 17, 25, pl. xlii, figs. 2, 27, 28.
Haloptilus chierchiæ, Sars, 1925, p. 245, pl. lxx, figs. 1–13.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 59 females.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 26 females, 1 male.

Sta. 76, Gulf of Oman, 1500–0 m., 50 females, 2 males.

Sta. 145 C, Maldive area, 500–0 m. vertical, 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 2 females.

DESCRIPTIVE NOTES.—♀. Total length 4·6 to 4·8 mm.

TEXT-FIG. 49.—*Haloptilus chierchiæ* (Giesbrecht). A, Mandible, ♀. B, Mandible, ♂. C, 1st maxilla, ♀. D, 1st maxilla, ♂. E, 2nd maxilla, ♀. F, 2nd maxilla, ♂. G, Maxilliped, ♂. H, 1st leg, ♀. I, 5th pair of legs, ♂.

The proportional lengths of the cephalothorax and abdomen are as 83 to 17. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
471	137	56	56	88	74	23	18	28	49 = 1000.

The separation of the cephalon and the 1st thoracic segment appears to be incomplete ; a line of demarcation is visible across the dorsum but disappears in the lateral region. Thoracic segments 4 and 5 are fused. The forehead is acutely rounded and is devoid of any crest. The posterior thoracic margin is rounded. The genital segment is longer than the three following segments together.

The 1st antenna overreaches the furcal rami by about the last 6 or 7 segments. The proportional lengths of the various segments are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
73	16	19	19	25	25	27	29	32	33	36	44	51	51	48	49	51	54

19.	20.	21.	22.	23.	24.	25.
44	39	44	44	57	53	37 = 1000.

Segments 7, 9, 12, 14, 18, 21, 23, 24 and 25 all bear long setæ. The distal seta on segment 8 is stout but very short.

The 2nd antenna and mouth-parts are as described and figured by Giesbrecht (1892), and Sars (1925).

The 1st leg (Text-fig. 49, H) agrees exactly with the figure given by Giesbrecht (1892, pl. xxvii, fig. 25) ; the distal outer angle of exopod 1, 2 and 3 at the base of the marginal spines is fringed with a comb of minute spinules.

Associated with these females were a few males.

♂. Total length, 4·05 mm.

The proportional lengths of the anterior and posterior regions of the body are as 80 to 20. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
437	146	74	61	94	45	29	20	16	29	49 = 1000.

The forehead is rounded and without any crest or prominence.

The right 1st antenna is modified to form a grasping organ. The proportional lengths of the various segments of the unmodified antenna differ somewhat from those of the female and are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
77	21	23	24	28	29	29	32	36	39	40	46	51	52	50	48	50	55

19.	20.	21.	22.	23.	24.	25.
45	35	38	38	45	45	24 = 1000.

In the right antenna the proportional lengths of the terminal six segments are as follows : 70, 71, 116, 71, 56 and 25. Segment 17 bears distally a horizontal spine that projects

over the proximal third of segment 18. Segment 18 bears a horizontal spine that arises at the junction of about the middle and distal thirds and nearly reaches the end of the segment. The portion beyond the joint, representing segments 19–21, bears two spines; the proximal arises near the proximal end of the segment and projects to about half the length; the distal spine arises near the junction of the proximal and middle thirds of the segment and reaches the distal end. The combined segment 22–23 bears distally a long straight spine that extends to the end of the appendage.

The 2nd antenna closely resembles that of the female, the exopod being very short and composed of 8 segments; segments 1 and 2 are clearly separate.

The 1st and 2nd maxillæ differ somewhat from those of the female.

In the 1st maxilla (Text-fig. 49, D) the number of spines on the 1st inner lobe is reduced; in the female there are 7 spines and in addition a delicate seta, whereas in the male there are only 5 spines and one seta: furthermore, in the endopod the segments are fused in the male, whereas in the female the 1st and 2nd segments are separate and a trace of separation of the 3rd segment can be detected.

The 2nd maxilla (Text-fig. 49, F) is less developed than in the female, as Giesbrecht has noted, and the setæ are shorter and more delicate, a condition that is especially noticeable in the spines arising from the 5th and 6th lobes.

In the maxilliped (Text-fig. 49, G) the spines arising from the various lobes are much more delicate than in the female, and the 2nd lobe bears only 2 setæ, instead of 3.

The swimming legs agree closely with those of the female, but in the 1st leg the combs of fine spinules at the base of the marginal spines on the segments of the exopod are absent.

In the 5th leg (Text-fig. 49, I) the appendages of the two sides are very nearly symmetrical. Each ramus is composed of three segments. In the right leg the 1st basal segment carries on its inner margin a blunt process. The 2nd basal bears a single seta. Exopods 1 and 2 each bear a somewhat delicate marginal spine, and exopod 3 bears two spines on the outer margin and one distally. In the left leg basal 1 bears a blunt small process on its inner margin. Basal 2 possesses a single seta. Exopods 1 and 2 each bear a delicate marginal spine and exopod 3 bears 3 spines. There are no inner setæ on any of the segments of the exopod in either leg. In both legs the 1st segment of the endopod is devoid of a seta, endopod 2 bears a single one, and endopod 3 bears 6 setæ.

Distribution.—This species has now been recorded from the North Atlantic Ocean near the Canary Islands and the Azores (Sars), the tropical Atlantic region (Wolfenden), the northern area of the Arabian Sea, the Gulf of Oman and the Maldive area (present records), the Laccadive Sea (Sewell), and the Pacific Ocean (Giesbrecht, Sars).

Haloptilus mucronatus (Claus).

Hemicalanus mucronatus, Giesbrecht, 1892, p. 384, pl. iii, fig. 10, pl. xxvii, figs. 11, 13, 19, pl. xlii, figs. 4, 6, 13, 14.
Haloptilus mucronatus, Sars, 1925, p. 249, pl. lxxiii, figs. 11–15.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m. vertical, 1 female.

Distribution.—In the Mediterranean Sea (Claus, Sars), the North Atlantic Ocean (Sars), the Gulf of Guinea (T. Scott), the Arabian Sea (present record), the Australian Barrier Reefs (Farran), and off New Zealand (Farran).

Haloptilus ornatus (Giesbrecht). (Text-fig. 50, H.)

Hemicalanus ornatus, Giesbrecht, 1892, p. 384, pl. xxvii, figs. 1, 6, 7, 21, 28; pl. xlii, figs. 1, 9, 19.
Haloptilus ornatus, Sars, 1925, p. 247, pl. lxxiii, figs. 1–5.

OCCURRENCE:

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 2 females.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

REMARKS.—The total length of these specimens ranged from 4·4 to 4·5 mm.; they are thus slightly smaller than Sars' examples from the North Atlantic Ocean, which measured 5·0 mm., and those of Giesbrecht from the Mediterranean Sea, which were 4·6 to 4·8 mm.

DISTRIBUTION.—The North Atlantic Ocean (Thompson, Sars, van Breemen), the Mediterranean Sea (Giesbrecht), the South Atlantic Ocean (Wolfenden), the Arabian Sea (present records), the Laccadive Sea (Sewell) and the Malay Archipelago (A. Scott).

Haloptilus oxycephalus (Giesbrecht).

Hemicalanus oxycephalus, Giesbrecht, 1892, p. 384, pl. xlii, figs. 7, 16.
Haloptilus oxycephalus, Sars, 1925, p. 252, pl. lxxiv, figs. 12–16.

OCCURRENCE:

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

DISTRIBUTION.—The Mediterranean Sea (Sars), South-east of Madagascar in the Indian Ocean (Wolfenden), the Arabian Sea (present records), and to the South of New Zealand and in the Antarctic Ocean (Farran).

Haloptilus validus Sars. (Text-fig. 50, A–G.)

Haloptilus validus, Sars, 1925, p. 241, pl. lxviii, figs. 1–14.

OCCURRENCE:

Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

♀. Total length 6·0 mm.

The proportional lengths of the anterior and posterior regions of the body are as 85·5 to 14·5. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
501	131	75	67	83	56	16	8	21	42 = 1000.

The forehead is produced in a small spinous projection. The posterior thoracic margins are bluntly rounded.

The 1st antenna overreaches the tip of the furcal ramus by about the last two segments. The proportional lengths of the various segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	75	15	17	17	18	21	22	23	29	29	35	45	54	60	62	66	66	65

19.	20.	21.	22.	23.	24.	25.
59	47	44	40	38	31	23 = 1000.

The proximal segments are provided with long plumose setæ.

TEXT-FIG. 50.—*Haloptilus validus* Sars, ♀. A, Lateral view. B, 2nd antenna. C, Mandible. D, 1st maxilla. E, 2nd maxilla. F, 1st leg. G, 5th leg. *Haloptilus ornatus* (Giesbrecht), ♀. H, 2nd maxilla.

In the 2nd antenna (Text-fig. 50, B) the exopod is less than half the length of the endopod. It appears to be composed of only 6 segments, of which the 1st is nearly equal in length to the rest of the appendage.

The mandible (Text-fig. 50, C) is of the same general type as that of *H. chierchiæ.*

In the 1st maxilla (Text-fig. 50, D) the biting ramus tapers towards the distal end and bears only two stout serrated teeth and 4 delicate setæ. The 2nd inner lobe is small and rounded and bears a single long seta. The 3rd inner lobe bears 3 setæ. The 2nd basal segment bears 5 setæ, and the endopod is much reduced and forms a small rounded lobe bearing only two setæ. The endopod is long and comparatively slender and bears 10 setæ, of which the proximal 6 are well developed and the distal 4 are small and delicate. The outer lobe bears 3 very delicate proximal setæ and 6 well-developed distal ones.

The 2nd maxilla (Text-fig. 50, E) resembles that of *H. ornatus.* The 1st lobe bears 3 setæ and is produced in a small pointer process. Lobes 2, 3 and 4 each bear 2 setæ ; the 5th lobe bears one seta and a stout serrated spine. Lobe 6 bears a stout serrated spine and 2 setæ.

The swimming legs resemble those of other members of the genus.

In the 5th leg (Text-fig. 50, G) the 2nd basal segment bears externally a delicate seta that reaches the distal end of the exopod.

DISTRIBUTION.—This species has, up to the present time, only been recorded from the North Atlantic Ocean (Sars). The present record extends its range to the Arabian Sea.

Genus *Euaugaptilus* Sars.

Euaugaptilus, Sars, 1925, p. 260 ; Sewell, 1932, p. 313.

As Sars (1925, p. 260) has pointed out, the members of this genus differ from *Augaptilus* (*sensu stricto*) in the better development of the mandible and 1st maxilla, but that in the latter appendage there is a great deal of variability, which thus provides excellent specific characters. In a previous paper (1932, p. 312) I pointed out that the genus can be subdivided into groups in accordance with the degree of suppression found in the mandible, and especially in the 1st maxilla. Throughout the genus there is also a gradual reduction in the number of setæ that arise from the various lobes of the 2nd maxilla, so that this character also can be utilized for the further separation of species ; and finally certain species possess rows of small button-like projections on the terminal setæ of the 2nd maxilla and the maxilliped. Farran (1906, p. 71) has pointed out that " it is impossible to use any arrangement which does not separate species which in some points closely resemble each other." Since my account was published, further investigation has rendered it necessary to subdivide some of the groups into sub-groups.

GROUP I :

The mandibular palp possesses two well-developed rami.

A. The maxilla is of normal type, the endopod and inner lobes 1, 2 and 3 all present ; in *indicus* the endopod is greatly reduced and bears only a single seta :

(*a*) 8 segments in the exopod of the 2nd antenna.
Euaugaptilus nodifrons Sars.
E. indicus Sewell.

(*b*) 7 segments in the exopod of the 2nd antenna.

Euaugaptilus elongatus Sars.
E. farrani Sars.
E. maxillaris Sars.

(*c*) 6 segments in the exopod of the 2nd antenna.

? *Euaugaptilus simplex* Wolfenden.

B. In the 1st maxilla inner lobes 1 and 3 are present, but lobe 2 has been suppressed; the endopod is present.

Euaugaptilus humilis Farran.

C. Inner lobes 2 and 3 are suppressed: but an endopod is still present.

Euaugaptilus penicillatus Sars.

Group II:

In the 1st maxilla inner lobes 1, 2 and 3 are all present, but the endopod is wanting. The mandibular palp possesses two rami.

(*a*) 8 segments in the exopod of the 2nd antenna.

Euaugaptilus fungiferus Steuer.
E. grandicornis Sars.
E. laticeps Sars (= *placitus* A. Scott).
E. squamatus (Giesbrecht).
E. sub-filigerus (Wolfenden).

(*b*) 7 segments in exopod of 2nd antenna.

? *Euaugaptilus antarcticus* (Wolfenden) (? = *laticeps*).
E. filigerus (Claus).
E. magnus (Wolfenden).
E. oblongus Sars.
E. rostratus Esterly.
E. tenuispinus Sars.

Group III:

In the 1st maxilla inner lobes 1 and 2 are present; lobe 3 and the endopod are missing.

A. The mandibular palp possesses two rami.

(*a*) 8 segments in the exopod of the 2nd antenna.

Euaugaptilus affinis Sars.
E. angustus Sars.
E. facilis (Farran).
E. gracilis Sars.
E. propinquus Sars.
E. palumboi (Giesbrecht).

(*b*) 7 segments in the exopod of the 2nd antenna.

Euaugaptilus digitatus Sars.

(*c*) 4 segments only in the exopod of the 2nd antenna.

Euaugaptilus clavatus Sars.
E. gibbus Wolfenden.

B. The mandibular palp bears a normal exopod, but the endopod is much reduced.

Euaugaptilus longimanus Sars.

C. The mandibular palp bears only a single, much reduced ramus.

Euaugaptilus longicirrhus Sars.

Group IV :

In the 1st maxilla inner lobes 2 and 3 and the endopod are absent; inner lobe 1 is considerably reduced and bears only 2–5 setæ.

A. The endopod of the mandibular palp is present but may be much reduced.

(*a*) 8 segments in the exopod of the 2nd antenna.

Euaugaptilus bullifer (Giesbrecht).
E. truncatus Sars.

(*b*) 7 segments in the exopod of the 2nd antenna.

Euaugaptilus vicinus Sars.

B. The endopod of the mandibular palp is absent or is represented only by a single seta. 8 segments in the exopod of the 2nd antenna.

Euaugaptilus hecticus (Giesbrecht).
E. latifrons Sars.
E. rigidus Sars.
E. tenuicaudis Sars.

Throughout the whole genus there is a tendency for the number of setæ arising from the lobes of the 2nd maxilla to be reduced ; this reduction reaches its climax in the species belonging to Group IV, as is clearly seen in the following table :

Group I :

A.

	Number of setæ on the lobes of the 2nd maxilla.					
Lobes :	1.	2.	3.	4.	5.	6.
Euaugaptilus nodifrons .	3 (+1)	3	3	3	3	4
E. indicus . . .	3 (+1)	3	3	3	3	3
E. simplex . . .	—	2	3	3	3	4 (? 3)*
E. maxillaris . . .	3	2	2	3	2	3
E. farrani . . .	—	2	2	3	2	3
E. elongatus . .	3 (+1)	2	2	3	2	3

Group I—(*contd.*):

	Number of setæ on the lobes of the 2nd maxilla.					
Lobes:	1.	2.	3.	4.	5.	6.
B.						
E. humilis	3	2	2	3	2	3
C.						
E. penicillatus	2	1	2	3	3	3
Group II:						
E. laticeps *E. tenuispinus* *E. squamatus*	3 (+1)	2	2	3	2	3
E. antarcticus	—	2	2	3	2	3†
E. magnus *E. oblongus* *E. fungiferus* *E. sub-filigerus*	3 (+1)	1	2	3	2	3
E. filigerus	1	1	2	3	2	3
Group III:						
E. digitatus *E. grandicornis* *E. gibbus*	3	2	2	3	2	3
E. facilis	3	2	2	3	2	3 or 2
E. clavatus	3	2	2	3	3	1
E. palumboi	3	2	2	3	2	1
E. gracilis	3	1	2	3	2	3
E. angustus	2	2	2	2	2	3
E. affinis	2	1	2	3	2	1
E. propinquus	2	1	2	2	2	1
E. sp. juv.	0	2	2	3	2	3
E. longicirrhus	0	1	2	3	3	3
Group IV:						
A.						
E. truncatus	2	1	2	3	2	3 (?)
E. bullifer	2	1	2	3	2	1
E. longimanus	1	1	1	3	2	3
E. vicinus	0	1	2	3	2	1
B.						
E. tenuicaudis	2	1	2	2	2	1
E. rigidus	2	1	1	2	2	1
E. latifrons	1	0	1	2	2	3
E. hecticus	0	0	1	2	2	1

* Wolfenden (1911, p. 346) states that there are 4 setæ on this lobe, but he only figures 3 (*vide* fig. 76*b*).

† In the text Wolfenden (1911, p. 335) states that the 2nd and 4th–6th lobes bear 2, 2, 3, 2 setæ, but in his figure (pl. xxxvi, fig. 7) he shows the number of setæ given here.

In a genus in which there is so much variation in the structure of the mouth-parts, it is only to be expected that some variation should also be found in the 2nd antenna. In certain species that I believe to be synonymous, such as *Euaugaptilus nodifrons* and *simplex* and *Euaugaptilus laticeps* and *antarcticus* respectively, the number of segments in the exopod are stated to be 8 and 6 in the first pair and 8 and 7 in the second respectively. In *Euaugaptilus elongatus* this ramus is stated to possess 7 segments, but in the present example there are eight present, though the separation between the 1st and 2nd segments is not quite complete : similarly in *Euaugaptilus laticeps* there are stated to be 8 segments, whereas in *E. antarcticus* Wolfenden states that there are only 7, but in the present specimen the separation between segments 7 and 8 is incomplete on one aspect of the ramus.

There is in the genus a certain amount of variation in the segmentation of the swimming legs and also in the number of setæ arising from certain joints. In the great majority of species the setal formula for these legs is as follows :

	Endopod.			Exopod.		
	1.	2.	3.	1.	2.	3.
P 1	1	2	5	1	1	4, 1, 3
P 2	1	2	7	1	1	5, 1, 3
P 3	1	2	8	1	1	5, 1, 3
P 4	1	2	7	1	1	5, 1, 3
P 5	1	1	6	0	1	3, 1, 2

This formula is found in

Euaugaptilis nodifrons (= *simplex*).
E. elongatus.
E. maxillaris.
E. laticeps (= *antarcticus, placitus*).
E. squamatus.
E. filigerus.
E. magnus.
E. oblongus.
E. tenuispinus.
E. facilis.
Euaugaptilus gracilis.
E. gibbus.
E. propinquus.
E. bullifer.
E. digitatus.
E. penicillatus.
E. truncatus.
E. laticeps.
E. vicinus.
E. rigidus.

In two species, namely, *Euaugaptilus angustus* and *E. grandicornis*, the 3rd segment of the endopod of the 2nd leg bears only 6 setæ instead of 7. In *E. clavatus* the terminal segment of the endopod of the 1st leg bears only 4, instead of 5 setæ. In *E. longimanus* the 2nd segment of the endopod of the 1st leg bears only a single seta instead of two. In *E. longicaudatus*, *E. longimanus* and *E. affinis* the 3rd segment of the endopod of the 3rd leg bears 7, instead of 8, setæ.

In five species, namely—

Euaugaptilus latifrons,
E. farrani,
E. longicirrhus,
E. tenuicaudis,
E. palumboi,

the endopod of the 1st leg consists of only two segments instead of the usual three, and in *longicirrhus* the exopod has undergone the same reduction. In three of these species, *latifrons*, *palumboi* and *farrani*, the number of setæ arising from the endopod of the 2nd leg is normal, namely 1, 2, 7; and in *longicirrhus* and *tenuicaudis* there is only one seta on the 2nd segment, the formula being 1, 1, 7, instead of 1, 2, 7. In *E. palumboi* the 3rd segment of the endopod of the 5th leg bears only 5 setæ instead of 6, and in *E. tenuicauda* the distal two segments of this ramus are fused into one, though the number of setæ remains unchanged, so that the formula is 1, 6, instead of 1, 1, 5.

The various species can further be separated into two groups by the presence or absence of an external marginal seta on the 2nd basal segment of the 1st swimming leg. Such a seta has been recorded in the following species:

Euaugaptilus angustus.
E. bullifer.
E. cornutus.
E. elongatus.
E. facilis.
E. filigerus.
E. gibber.
Euaugaptilus grandicornis.
E. indicus.
E. longicirrhus.
E. longimanus.
E. nodifrons.
E. tenuispinus.

It is absent in the following species:

Euaugaptilus fungiferus.
E. laticeps.
E. latifrons.
Euaugaptilus magnus.
E. oblongus.

Group I.

Three species that I include in this group were present in the collection, *Euaugaptilus nodifrons* Sars, *E. indicus* Sewell, and *E. elongatus* Sars. As Farran (1906, p. 71) has pointed out, "*Augaptilus elongatus* is apparently the most primitive form, and in it, as also in *A. nodifrons*, the endopodite of the maxilla is indicated as a distinct joint, thus forming a link with the genus *Haloptilus*."

A third species which may be regarded as an aberrant member of this group, *E. penicillatus* Sars, was also present in the collection: in this species the endopod of the 1st maxilla is present, but both 2nd and 3rd inner lobes have been suppressed.

Euaugaptilus indicus Sewell. (Text-fig. 51, a–c.)

Euaugaptilus indicus, Sewell, 1932, p. 319, text-fig. 105, *a–j*.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 juv.

Descriptive Notes.—The single specimen was in the fifth Copepodid stage.

Stage V: ♀. Total length, 6·47 mm.

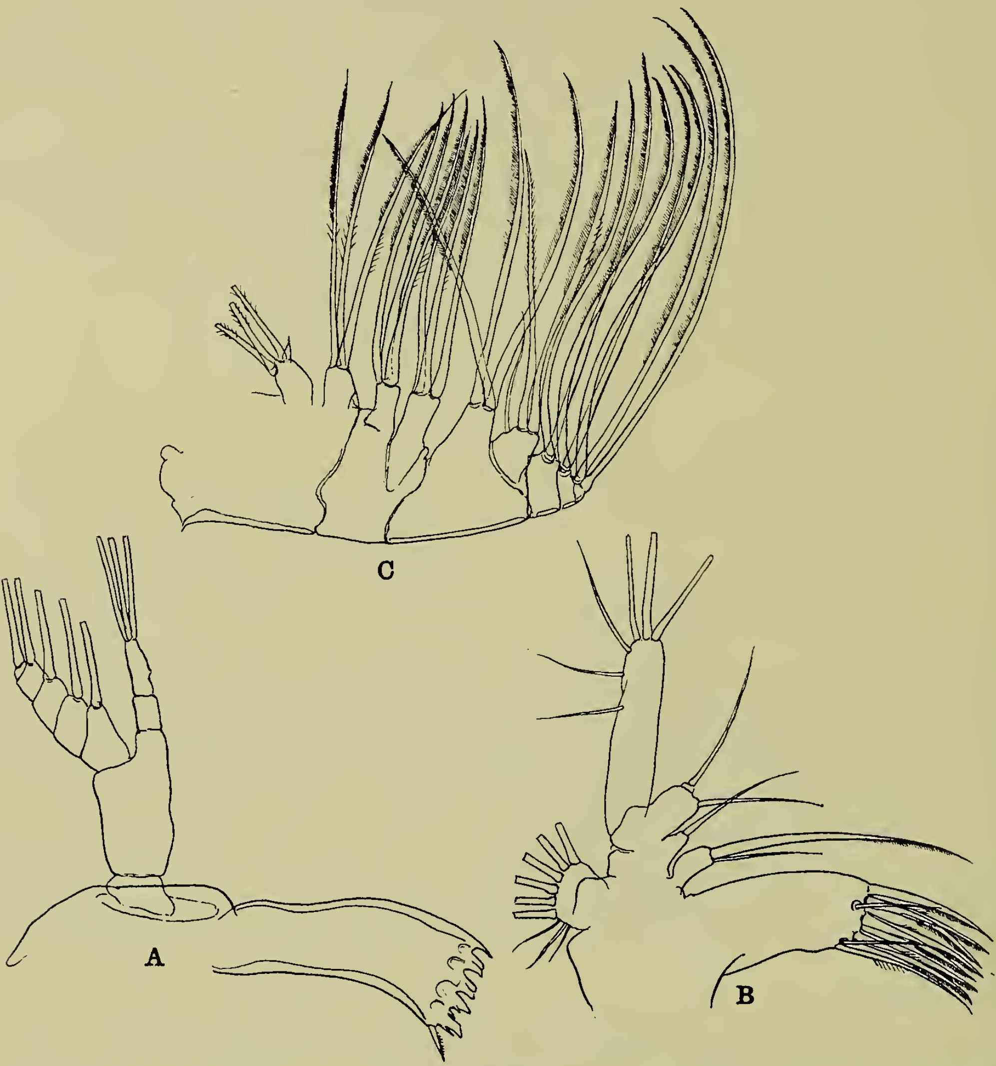
The proportional lengths of the anterior and posterior regions of the body are as 75 to 24, as compared with 78 to 22 in the adult. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
437	103	67	64	85	51	26	28	72	67 = 1000.

In the 1st antenna the proportional lengths of the segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Stage V	75	18	21	21	25	25	25	23	25	29	43	41	50	50	50	50	55	55
Adult	67	10	22	22	22	22	24	26	29	31	34	45	50	53	54	56	56	56

Segment	19.	20.	21.	22.	23.	24.	25.	
Stage V	58	45	46	48	58	48	25	= 1000.
Adult	57	46	46	42	50	48	25	= 1000.



Text-fig. 51.—*Euaugaptilus indicus* Sewell ; Stage V, ♀. A, Mandible. B, 1st maxilla. C, 2nd maxilla.

The 2nd antenna resembles that of the adult.

In the mandible (Text-fig. 51, A) the biting ramus is as figured. The exopod consists of 5 segments, each of which bears a single stout seta ; the endopod is composed of two segments, of which the distal bears three setæ.

In the 1st maxilla (Text-fig. 51, B) the 1st inner or biting lobe bears 7 stout spines and 3 more delicate ones ; the 2nd inner lobe bears 2 unequal setæ and the 3rd lobe carries a single seta. The 2nd basal segment in the present specimen bears 1 seta, and the endopod is represented by a small raised lobe on the distal margin that bears a single seta.

The 2nd maxilla (Text-fig. 51, c) is well developed and the various lobes bear the following spine-like setæ: lobe 1, 3 setæ and an additional, small pointed process; lobe 2, 3 setæ: lobe 3, 3 setæ: lobe 4, 3 setæ; lobe 5, 3 setæ; lobe 6, two large setæ and 1 smaller one. The terminal three segments of the endopod bear 7 setæ. None of these setæ are provided with "buttons."

The maxilliped is well developed, but the various lobes have not yet assumed their full complement of setæ. The 1st basal segment bears 2, 3 and 3 setæ on the three lobes; the 2nd basal bears 2 and 2 setæ; the five segments of the endopod bear 3, 3, 2, 2 and 1 large setæ, and the distal segment also carries 4 small setæ.

The 1st–4th swimming legs are as in the adult. The 5th pair of legs possess only two segments in the rami.

Distribution.—Up to the present time this species has been recorded from the Laccadive Sea (Sewell) and the Arabian Sea (present record).

Euaugaptilus elongatus Sars. (Text-fig. 52, a–f.)

Augaptilus elongatus, Farran, 1906, p. 71.
Euaugaptilus elongatus, Sars, 1925, p. 270, pl. lxxxiv, figs. 1–13.

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Descriptive Notes.—♀. Total length 5·00 mm.

The proportional lengths of the anterior and posterior regions of the body are as 70 to 30. The proportional lengths of the various segments of the body are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–3.	Abd. 4.	Abd. 5.	Furca.
408	122	61	46	70	119	43	51	80 = 1000

The 1st antenna overreaches the tip of the furcal ramus by the last five or six segments. The proportional lengths of the individual segments are as follows:

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18
	64	15	20	21	24	24	25	25	26	27	30	39	46	49	51	53	59	61

19.	20.	21.	22.	23.	24.	25.
58	47	51	52	54	44	35 = 1000

In the 2nd antenna (Text-fig. 52, a) the endopod and exopod are of approximately equal length. The exopod is composed of eight segments; the 3rd segment appears to be devoid of a seta.

The mandible (Text-fig. 52, b) possesses a well-developed palp, the two rami being of approximately equal length. The biting ramus is well developed, but the biting edge is much more oblique than in either *nodifrons* or *indicus*; the teeth are arranged in three groups, possessing 2, 2 and 3 teeth respectively.

The 1st maxilla (Text-fig. 52, c) agrees with the description given by Farran (1906), but on the right side the 2nd basal segment bears 4, instead of 3, setæ.

In both the 2nd maxilla (Text-fig. 52, d) and the maxilliped the distal setæ are fringed

TEXT-FIG. 52.—*Euaugaptilus elongatus* Sars, ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, 2nd maxilla. E, 1st leg. F, 5th leg.

with large " buttons," and in each seta one can trace a gradual transition from hairs, through small spines to " buttons."

In the 1st leg (Text-fig. 52, E) the 2nd basal segment bears a retroverted seta near the distal outer angle.

In the 5th leg (Text-fig. 52, F) the 2nd basal segment bears an extremely long, delicate seta, the total length of which is about twice the length of the exopod.

DISTRIBUTION.—Up to the present time this species has only been recorded from the North Atlantic Ocean (Sars, to the south of Davis Strait), Baffin Bay and the south-west of Iceland (Jespersen), and the west coast of Ireland (Farran). The present record extends its distribution to the Indian Ocean, Arabian Sea.

Euaugaptilus nodifrons Sars. (Text-fig. 53, A–E.)

Euaugaptilus nodifrons, Sars, 1925, p. 267, pl. lxxxii; Sewell, 1932, p. 316, text-fig. 104, *a–j*.
? *Augaptilus simplex*, Wolfenden, 1911, p. 345, text-fig. 76.

OCCURRENCE:

Sta. 61 A, Northern part of Arabian Sea, 1000–0 m., 12 specimens; 1500–0 m., 22 specimens.
Sta. 61 C, Northern part of Arabian Sea, 1500–0 m., 17 specimens.
Sta. 76, Gulf of Oman, 1500–0 m., 2 females.
Sta. 96, Central part of Arabian Sea, 635–400 m., 2 females, 1 male.
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m. vertical, 1 female.
Sta. 172, Central area of Arabian Sea, 200–0 m., 2 females; 850–0 m., 1 female.

REMARKS.—The form described by Wolfenden (*loc. cit.*) under the name *Augaptilus simplex* resembles *E. nodifrons* extremely closely. Almost the only point of difference that I can detect in Wolfenden's account is that lobe 6 of the 2nd maxilla is stated to possess four setæ; he, however (fig. 76, *b*), shows only two large setæ and one smaller one, and in *nodifrons* there are only two large setæ in addition to the smaller one.

In one of the present specimens the exopod of the 3rd leg (Text-fig. 53, E) showed an unusual modification: from the outer margin of the 2nd segment there arose a plumose seta situated about the middle of the length and from the distal angle the usual short spine; in exopod 3 the 1st and the 3rd marginal spines were doubled, so that, in all, 5 spines sprang from this margin. The terminal spine was much shorter than the normal spine on the other leg and was like a seta in shape.

DISTRIBUTION.—The North Atlantic Ocean (Sars), the coast of Ireland (Farran), the South Atlantic (Wolfenden), the Arabian Sea and Gulf of Oman (present records), and the Laccadive Sea (Sewell). If *E. simplex* (Esterly) is, as I suspect, a synonym, then the distribution extends to the eastern Pacific Ocean.

Euaugaptilus penicillatus Sars.

Euaugaptilus penicillatus, Sars, 1925, p. 294, pl. c, figs. 1–15.

OCCURRENCE.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

DISTRIBUTION.—This species was originally taken in the North Atlantic to the west of Gibraltar (Sars). It has since been taken on the west of Greenland (Jespersen). The present record extends its distribution to the Arabian Sea.

Group II.

Four species, that I include in this group, are present, namely, *Euaugaptilus laticeps*, *E. magnus*, *E. oblongus* and *E. tenuispinus*. In all these species the endopod of the 1st maxilla is wanting, unless it is represented in *E. laticeps* by a single seta: the 2nd basal segment bears three setæ in this species, one projecting distally and two medially; in *E. tenuispinus* it bears two setæ, in *E. magnus* it may have one or two, and

Text-fig. 53.—*Euaugaptilus nodifrons* Sars. A, 2nd antenna. B, 1st maxilla. C, 2nd maxilla. D, 2nd leg. E, Abnormal exopod of 3rd leg.

in *E. oblongus* it has only a single one. In all four species both the 2nd and 3rd inner lobes are present; the 2nd lobe bears only one seta, but the 3rd lobe bears only one in *tenuispinus* and *magnus* and has two in *laticeps* and *oblongus*. In all four the spines on the 1st inner lobe are provided with rows of small "buttons," and so also is the single spine-like seta arising from the 2nd inner lobe.

In these species the blade of the mandible is tapering, and in *magnus*, *laticeps* and *tenuispinus* has the same basic pattern ; but in *oblongus*, though it is tapering, the number of teeth is markedly less than in the other species. Judging from the shape of the mandible, *E. californicus*, *romanus* and *depressus*, very inadequately described and figured by Esterly (1913) from the Californian coast, would seem to be related to the species of this group.

Sars (1925, p. 286) in his account of *E. grandicornis* figures the 1st maxilla as devoid of a 3rd inner lobe ; while agreeing in most other respects, the present specimens that I have referred to this species possess a small 3rd lobe bearing a single seta. Relying on Sars' account I placed this species in Group III, but it must be transferred to Group II. The character of the biting ramus of the mandible in this species also agrees with the others in the group.

Euaugaptilus grandicornis Sars. (Text-fig. 54, A–F.)

Euaugaptilus grandicornis, Sars, 1925, p. 286, pl. xciv.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 2 females, adult.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 5 females, adult, 2 juv.

Descriptive Notes.—♀. Total length, 6·17 mm.

This is rather smaller than Sars' examples from the North Atlantic.

The anterior lip of the mouth (Text-fig. 54, A) is strongly chitinized, and on either side of the middle line is produced backwards in a rounded papilla, on the tip of which a series of well-developed glands open ; on either side of this papilla the margin slopes forwards and outwards, and about half way along its length is produced in another rounded eminence, on the inner face of which another gland opens. The surface of the labrum is provided with three rows of fine hairs, an anterior crossing the middle line and two postero-lateral.

The 1st antenna overreaches the tip of the furcal rami by about the last 7 segments. The proportional lengths of the segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	57	17	24	26	29	29	29	29	32	32	38	47	51	50	51	55	58	58

19.	20.	21.	22.	23.	24.	25.	
58	43	42	42	45	34	24	= 1000

In the 2nd antenna the exopod consists of 8 segments, but the joint between the 7th and 8th is not very well marked.

The mandible is as figured by Sars (*loc. cit.*, pl. xciv, fig. 6).

The 1st maxilla (Text-fig. 54, B) differs slightly from the account and figure given by Sars ; the 1st inner lobe bears 11 setæ, the larger ones being fringed with spinules ; the 2nd inner lobe bears a single stout and long seta ; the 3rd inner lobe, not shown by Sars, is present, though of a reduced size, and bears a single rather small seta ; the portion of the appendage that corresponds to the 2nd basal segment bears 3 setæ directed inwards towards the mouth, and a fourth one that projects somewhat distally ; possibly this repre-

sents the remains of the endopod. The exopod bears 8 setæ, of which the four outer are of moderate size, the 5th is very long and stout, the 6th is large, and the 7th and 8th are small.

Text-fig. 54.—*Euaugaptilus grandicornis* Sars, ♀. A, The glands of the anterior lip of the mouth. B, 1st maxilla. C, 2nd maxilla. D, Maxilliped. E, Exopod of 3rd leg, abnormal. F, Exopod of 4th leg, abnormal.

In the 2nd maxilla (Text-fig. 54, C) and maxilliped (Text-fig. 54, D), which possess the usual form, the distal setæ are provided with discrete hairs in the proximal half of their

length, and distally are fringed with structures that appear to be small, closely-set "buttons."

The swimming legs are of the usual type. The exopods of both the 3rd and 4th legs on one side are abnormal, probably as a result of injury (Text-fig. 54, E and F).

This species is tinged a yellow colour, which is especially marked on the 2nd maxilla, the maxilliped and the swimming legs.

Distribution.—Hitherto known only from the North Atlantic Ocean, west of the Azores (Sars): the present record extends the distribution to the Arabian Sea.

Euaugaptilus laticeps Sars. (Text-fig. 55, A–H: Text-fig. 56, A–D.)

Euaugaptilus laticeps, Sars, 1925, p. 264, pl. lxxx, figs. 1–14.
Augaptilus antarcticus, Wolfenden, 1911, p. 334, pl. xxxvi, figs. 6, 7, text-fig. 70, *a–f*.
Augaptilus placitus, A. Scott, 1909, p. 137, pl. xlii, figs. 10–19.

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 3 females, adult, 1 juv.
Sta. 172, Central area of Arabian Sea, 850–0 m., 1 juv.

Descriptive Notes.—Adult: ♀. Total length 8·33 mm. Wolfenden (*loc. cit.*, 1911) gives the length of *antarcticus* as 8·55 mm., and A. Scott (*loc. cit.*, 1909) gives that of *placitus* as 10·0 mm.

The proportional lengths of the anterior and posterior regions of the body are as 80 to 20 in the present specimen; Wolfenden gives the proportions in *antarcticus* as 6·75 to 1·8, or 79 to 21. The proportional lengths of the various segments of the body are as follows, and for purposes of comparison I have given the corresponding lengths in an immature example in Stage IV:

	Cephalon, Th 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
Adult	435	128	70	64	95		80		27	44	57 = 1000
Stage IV	439	138	78	69	80	47	31		56		62 = 1000

From the above it seems clear that during development there is a progressive reduction in the lengths of the cephalon and the anterior 4 thoracic segments: in the 5th thoracic segment and the abdominal segments the process is in the opposite direction, the segments exhibiting a relative lengthening: but in the furcal rami there is again a shortening, similar to that which takes place in the anterior region.

The 1st antenna overreaches the furcal rami by several segments; Wolfenden (1911) states that in *antarcticus* they overreach by six segments, whereas A. Scott gives three segments in *placitus*. In the present specimens they overreach the furca by some six segments, as in *antarcticus*.

The proportional lengths of the various segments are as follows:

Segment.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Stage VI	68	16	24	24	27	29	29	30	32	36	40	46	52	58	49	50	52	58
Stage IV	69	14	18	18	24	24	24	25	26	30	35	46	48	48	40	45	50	55

	19.	20.	21.	22.	23.	24.	25.
Stage VI	49	41	41	41	46	38	24 = 1000
Stage IV	57	50	52	54	58	51	38 = 1000

For purposes of comparison I have also given the proportional lengths of the segments in Stage IV.

In the 2nd antenna (Text-fig. 55, A) the endopod is about $1\frac{1}{2}$ times the length of the

TEXT-FIG. 55.—*Euaugaptilus laticeps* Sars, ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, One of the spinse on the 1st inner lobe of 1st maxilla. E, 2nd maxilla. F, Maxilliped. G, 1st leg. H, 5th leg.

exopod. The exopod arises close to the proximal end of the 2nd basal segment: it consists of 8 segments, of which only the 8th bears setæ. In the endopod the 1st segment is fringed with a band of hairs along its inner margin and there is a clump of hairs on the inner aspect of the 2nd segment, exactly as Wolfenden has figured in *antarcticus* (1911, fig. 70, *a*).

The mandible (Text-fig. 55, B) is exactly as figured by A. Scott in *placitus*, except that the endopod bears only six short setæ, whereas Scott states that there are seven in his example. In stage IV only five setæ are present in this situation.

TEXT-FIG. 56.—*Euaugaptilus laticeps* Sars. Stage IV. A, Mandible. B, 1st maxilla. C, 2nd maxilla. D, Maxilliped.

In the 1st maxilla (Text-fig. 55, C) the exopod bears three large and three small setæ, as described by Wolfenden in *antaracticus*. The anterior seven spines on the 1st inner lobe and the single spine on the 2nd inner lobe are all densely fringed in the distal half of their length with numerous small buttons, closely crowded together, thus giving the appearance of a mosaic pavement (Text-fig. 55, D).

The 2nd maxilla (Text-fig. 55, E) is of the usual type. The various lobes bear 3, 2, 2, 3, 2, 3 setæ, and, in addition, on the 1st lobe there is a very small rudimentary seta, as in *E. nodifrons*.

In the maxilliped the 1st basal segment bears 1, 3 and 3 setæ on the three lobes: the 2nd segment bears 2 groups of 2 setæ; and the 1st and 2nd segments of the endopod

each bear 4 setæ, the 3rd and 4th segments 3 each, while the end segment bears 1 large seta and 3 small ones. The long setæ are armed with rows of " buttons."

In the 1st swimming leg (Text-fig. 55, G) basal 2 is without a seta on the outer border, as Wolfenden has noted in *antarcticus*.

The 2nd–5th legs resemble those of other members of the genus. In the 1st and 2nd legs I have been unable to detect any glands that open on the surface of the segments of the exopod; but in legs 3 and 4 a large gland opens by a wide pore near the base of the marginal spine on exopod 2, and others on segment 3 near the bases of the 1st and 3rd marginal spines. In the 5th leg (Text-fig. 55, H) a gland opens by a large pore near the base of the distal marginal spine.

STAGE IV.—One example in stage IV was taken at Sta. 172.

Total length, 5·29 mm.

The proportional lengths of the anterior and posterior region of the body are as 81 to 19. The proportional lengths of the various segments of the body and of the 1st antenna are as given above (*vide* p. 209).

The mouth parts (Text-fig. 56, A–D) already closely resemble those of the adult, but the full complement of setæ has not yet been developed :

	Stage IV.	Stage VI.
1st maxilla :		
Inner lobe 1	9 .	10
,, ,, 2	1 .	1
,, ,, 3	2 .	2
2nd basal	2 .	3
Outer lobe	3 large 1 small .	3 large 1 small
Exopod	3 large 2 small .	3 large 3 small
2nd maxilla :		
Lobe 1	3 .	3 + 1 small
,, 2	2 .	2
,, 3	2 .	2
,, 4	3 .	3
,, 5	2 .	2
,, 6	3 .	3
Maxilliped :		
Basal 1 { Lobe 1 . . .	1 .	1
Basal 1 { ,, 2 . . .	3 .	3
Basal 1 { ,, 3 . . .	3 .	3
,, 2 { ,, 4 . . .	2 .	2
,, 2 { ,, 5 . . .	2 .	2
Endopod 1	2 .	4
,, 2	2 .	4
,, 3	1 .	3
,, 4	1 .	3
,, 5	3 .	4

In the swimming legs the rami are incompletely divided ; in the 1st–4th legs there are only two segments in each ramus, and in the 5th leg each ramus is represented by a single segment. The setal formula is as follows :

	Endopod 1.	Endopod 2.	Exopod Inner 1.	Exopod Inner 2.	Exopod Outer 1.	Exopod Outer 2.
P. 1	1	7	1	4	1	3, 1
P. 2	1	9	1	5	1	3, 1
P. 3	1	8	1	5	1	3, 1
P. 4	1	7	0	5	1	3, 1
P. 5	6		3		3, 1	

As in the adult, there are no glands opening on the 1st and 2nd legs ; on legs 3 and 4 a single gland opens by a wide pore near the base of the distal marginal spine on exopod 2.

Distribution.—This species is widely distributed ; it has now been taken in the temperate region of the North Atlantic Ocean (Sars), off the Irish coast and in the Bay of Biscay (Farran), the Mediterranean Sea (Sars), the Arabian Sea (present record), the Laccadive Sea (Sewell), the Pacific Ocean (Sars) the Malay Archipelago (A. Scott, as *A. placitus*) and the Antarctic Ocean (Wolfenden, as *A. antarcticus*, Farran).

Euaugaptilus magnus (Wolfenden).

Augaptilus magnus, Wolfenden, 1904 (April), p. 122 ; *idem*, 1911, p. 341, pl. xxxvii, figs. 4–9, text-fig. 73, *a*, *b*.
Euaugaptilus magnus, Sars, 1925, p. 262, pl. lxxix, figs. 1–16.
Augaptilus fungiferus, Steuer, 1904 (June), p. 597.
Augaptilus validus, A. Scott, 1909, p. 138, pl. xliii, figs. 1–10.

Occurrence :

Sta. 61 A, Northern part of Arabian Sea, 1500–0 m., 3 juv. ; 2000–0 m., 1 female.
Sta. 61 C, Northern part of Arabian Sea, 1500–0 m., 4 females, 2 juv.
Sta. 96, Central part of Arabian Sea, 645–400 m., 2 females.
Sta. 172, Central part of Arabian Sea, 850–0 m., 3 juv. ; 2091–0 m., 1 female.
Sta. 186, Gulf of Aden, 600–0 m., 1 female.

Descriptive Notes.—Without a careful and complete re-examination of the types it is extremely difficult, if not impossible, to distinguish with certainty several species that have been described by various authors. Of the species that I refer to Group 2, the following possess 8 segments in the exopod of the 2nd antenna, *Euaugaptilus laticeps* Sars, *E. squamatus* (Giesbrecht), *E. subfiligerus* (Wolfenden), *E. magnus* (Wolfenden), *E. fungiferus* (Steuer), and *E. validus* (A. Scott). Of these *Euaugaptilus magnus* (Wolfenden), *E. fungiferus* (Steuer) and *E. validus* (A. Scott) are distinguished from the others by the complete absence of any rostral filaments. The present specimens appear to me to agree closely with the form described by Steuer under the name *fungiferus* ; Wolfenden (1911, p. 336, pl. xxxvi, fig. 8, text-fig. 71 *a*, *b*) has also described what he thought might be an example of *fungiferus* Steuer, but this account differs in several particulars from Steuer's original description, especially in the length and proportions of the furcal rami and in the number of setæ arising from the various lobes of the 1st maxilla. I am unable

to discover any valid difference between Steuer's *fungiferus* and A. Scott's *validus*, and I believe that they represent the same species. Wolfenden's species *E. magnus* also comes extremely close, and almost the only difference that I have been able to detect is in the shape of the terminal portion of the biting ramus of the mandible, that in *magnus* appears, so far as one can judge from the figures given by different authors, to be considerably less tapered than in *fungiferus*, though it bears exactly the same number of teeth ; but such a difference may well be due to the angle at which the ramus is viewed. So slight is this difference that I am inclined to regard all three forms as races of the same species, and Wolfenden's name *magnus* would have priority.

forma *fungiferus* Steuer. (Text-fig. 57, A–D.)

♀. Total length varies from 7·083 to 7·408 mm.

The proportional lengths of the cephalothorax and abdomen are as 76 to 24, and the cephalothorax is about twice as long as broad. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–3.	Abd. 4.	Abd. 5.	Furca.
414	130	65	65	85	129	34	34	44 = 1000

The furcal rami are as long as broad and the 2nd furcal seta is slightly longer than the others. There is a small accessory seta. The rostrum agrees exactly with the figure given by A. Scott, and forms a broadly rounded bifurcate papilla without any filaments.

The 1st antenna in most examples extends only as far as the tip of the furcal ramus, but in one example, that in other respects appeared to be identical with the rest, the appendage over-reached the top of the furcal ramus by the last two segments ; this variation is probably caused by the degree to which the body segments are telescoped into each other, thus slightly altering the total length.

The segments of the 1st antenna have the following proportional lengths :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	55	11	19	22	26	27	28	31	35	38	40	48	51	52	55	59	63	62

19.	20.	21.	22.	23.	24.	25.
56	42	44	36	38	34	28 = 1000

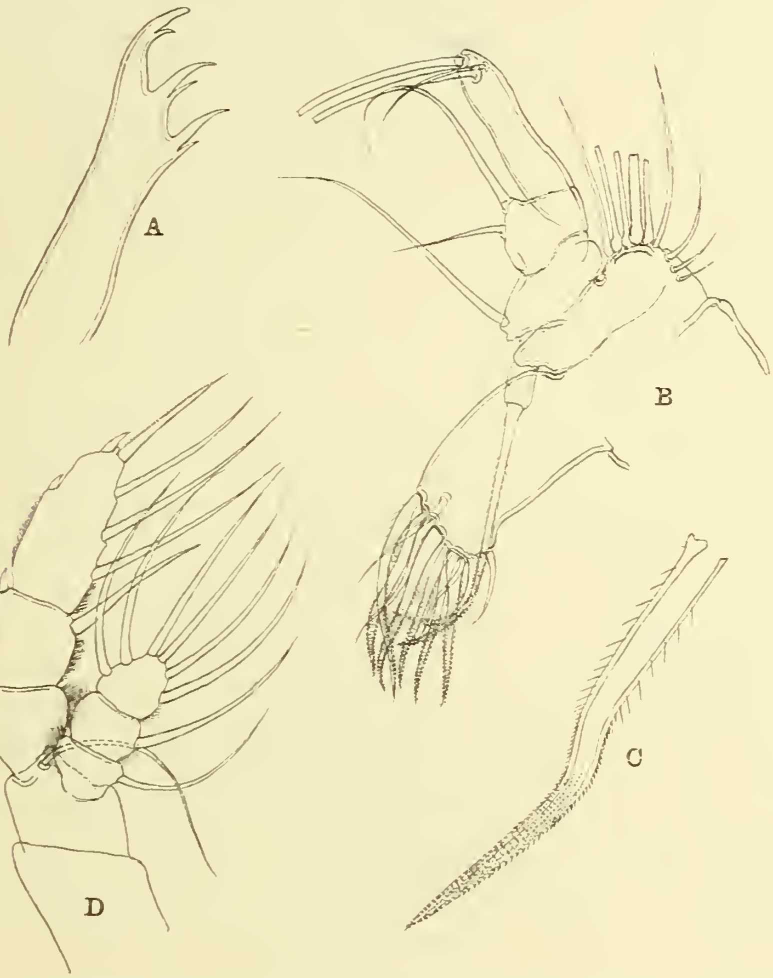
In the 2nd antenna the exopod consists of eight segments :

Wolfenden (1911, p. 337), in his description of what he took to be a specimen of *E. fungiferus* Steuer captured by the "Gauss" in the Atlantic Ocean, states that "Der Ausenast der hinteren Antennen ist nur so lang wie das 1. Glied des Innenastes, und dreigliedrig." Unfortunately, in attempting to group the various species (*vide* Sewell, 1932, p. 314) I followed Wolfenden and separated *E. fungiferus* from the others in the same group on account of this supposed reduction in the number of segments ; Steuer correctly gave eight as the number of segments in this ramus, and Scott's *validus* also possesses this number of segments.

In the mandible (Text-fig. 57, A) the biting ramus is elongate and tapers to a point, the biting edge being set very obliquely on the shaft, as A. Scott (1909, pl. xlii, fig. 6)

has shown in *E. validus*. Both Wolfenden and Sars figure the biting edge of the mandible in *E. magnus* as terminating much more bluntly.

The arrangement and number of setæ arising from the different parts of the 1st maxilla (Text-fig. 57, B) in the present specimens agree with the accounts of both *fungiferus* and *magnus*.



TEXT-FIG. 57.—*Euaugaptilus magnus* (Wolfenden), f. *fungiferus* Steuer. A, Biting ramus of mandible. B, 1st maxilla. C, One of the spines of the 1st inner lobe of 1st maxilla. D, 5th leg.

	fungiferus (Steuer).	*magnus* (Wolfenden).	Present specimens.
Le.	5 large 4 small (6th largest)	5 large 3 small (5th largest)	5 large 4 small (6th largest)
Li. 1	11	8 plus 2	8 plus 3
Li. 2	1 large	1 large	1 large
Li. 3	1	1	1
B. 2 (or endopod)	1	1	1 (or 2)
Exopod	3 large, 2 small	2 large, 1 small	2 large, 1 small

I have assumed that the above arrangement of the setæ on the 2nd basal and exopod of *fungiferus* is what Steuer intended ; in his account of the latter region he states that there are 2 large and 2 small on one side of the outer ramus, and 1 large on the other side. In both this species and in *laticeps* the setæ on the biting ramus are armed with rows of what appear to be small " buttons."

The 2nd maxilla agrees exactly in *fungiferus* and *magnus* and in the present examples.

	fungiferus (Steuer).	*magnus* (Wolfenden).	Present examples.
L. 1	3 and 1	3	3 and 1
L. 2	1	1	1
L. 3	2	2	2
L. 4	3	3	3
L. 5	2	2	2
L. 6	3	3	3
Ri. 1	2		2
Ri. 2	2	7	2
Ri. 3	3		3

Steuer records the presence of a small spine on the 1st lobe in addition to the 3 setæ, and the same is present in my examples.

In the maxilliped the proportional lengths of the two basal segments and the endopod appear to be identical in *magnus* and the present examples.

	Basal 1.	Basal 2.	Endopod.
magnus (Wolfenden)	20	20	15
Present specimens	65	65	50

I can find no differences in the structure of the swimming legs in all three forms.

Distribution.—If I am correct in regarding all these so-called species as forms of the same, the distribution is as follows : west coast of Greenland and south of Davis Strait (as *magnus*, Jespersen), in the North Atlantic Ocean (as *magnus*, Sars), off the Irish coast (as *magnus*, Wolfenden, Farran), the Bay of Biscay (as *magnus*, Farran), the South Atlantic Ocean (as *magnus*, Wolfenden), the Indian Ocean (as *fungiferus*, Steuer), the Arabian Sea and Gulf of Aden (present records), the Malay Archipelago (as *validus*, A. Scott).

Stage V. ♂. Total length, 6·33 mm.

The proportional lengths of the anterior and posterior region of the body are as 79 to 21. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
373	135	83	78	91	57	38	31	70	44 = 1000

In the 1st antenna the proportional lengths of the segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Right	65	14	21	23	27	29	29	29	31	33	34	45	47	49	52	54	60	60
Left	61	13	23	25	30	30	30	33	34	36	38	49	49	50	55	58	64	62

Segment	19.	20.	21.	22.	23.	24.	25.
Right	58	42	46	38	42	40	32 = 1000
Left	49	31	37	35	39	38	31 = 1000

On the left side segments 17, 18 and 19 are each produced in a spine that overlaps the following segment. Segments 3, 7, 9, 14, 18, 21 and 25 in both antennæ bear a long seta.

The 2nd antenna resembles that of the adult.

In the mouth parts the several appendages have attained the adult form, but the full complement of setæ has not yet been attained. The differences are shown below:

	Stage V.	Stage VI.
1st maxilla:		
Inner lobe 1	10	10
,, ,, 2	1	1
,, ,, 3	1	1
2nd basal	1	1 or 2
Outer lobe	8	9
Exopod	2 large 1 small	2 large 1 small
2nd maxilla:		
Lobe 1	3, 1 rudimentary	3
,, 2	1	1
,, 3	2	2
,, 4	3	3
,, 5	2	2
,, 6	3	3
Maxilliped:		
Lobe 1	1	1
,, 2	3	3
,, 3	3	3
,, 4	2	2
,, 5	2	2
Endopod 1	3	4
,, 2	3	4
,, 3	2	3
,, 4	2	3
,, 5	3	3

In the swimming legs the rami are three-jointed except in the 5th pair, in which there are only two segments present, segments 2 and 3 not yet having separated. The setal formula has attained its full development in the anterior four pairs of legs, and in the 5th pair the full complement of setæ and spines is present:

	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	2	5	1	1	4	1	1	2, 1
P. 2	1	2	7	1	1	5	1	1	3, 1
P. 3	1	2	8	1	1	5	1	1	3, 1
P. 4	1	2	7	1	1	5	1	1	3, 1
P. 5	1	7		0	4		1	3, 1	

In the adult female the formula for P 5 is 1 . 1 . 6 ; 0 . 1 . 3 ; 1 . 1 . 2, 1.

Euaugaptilus oblongus Sars. (Text-fig. 58, A–F.)

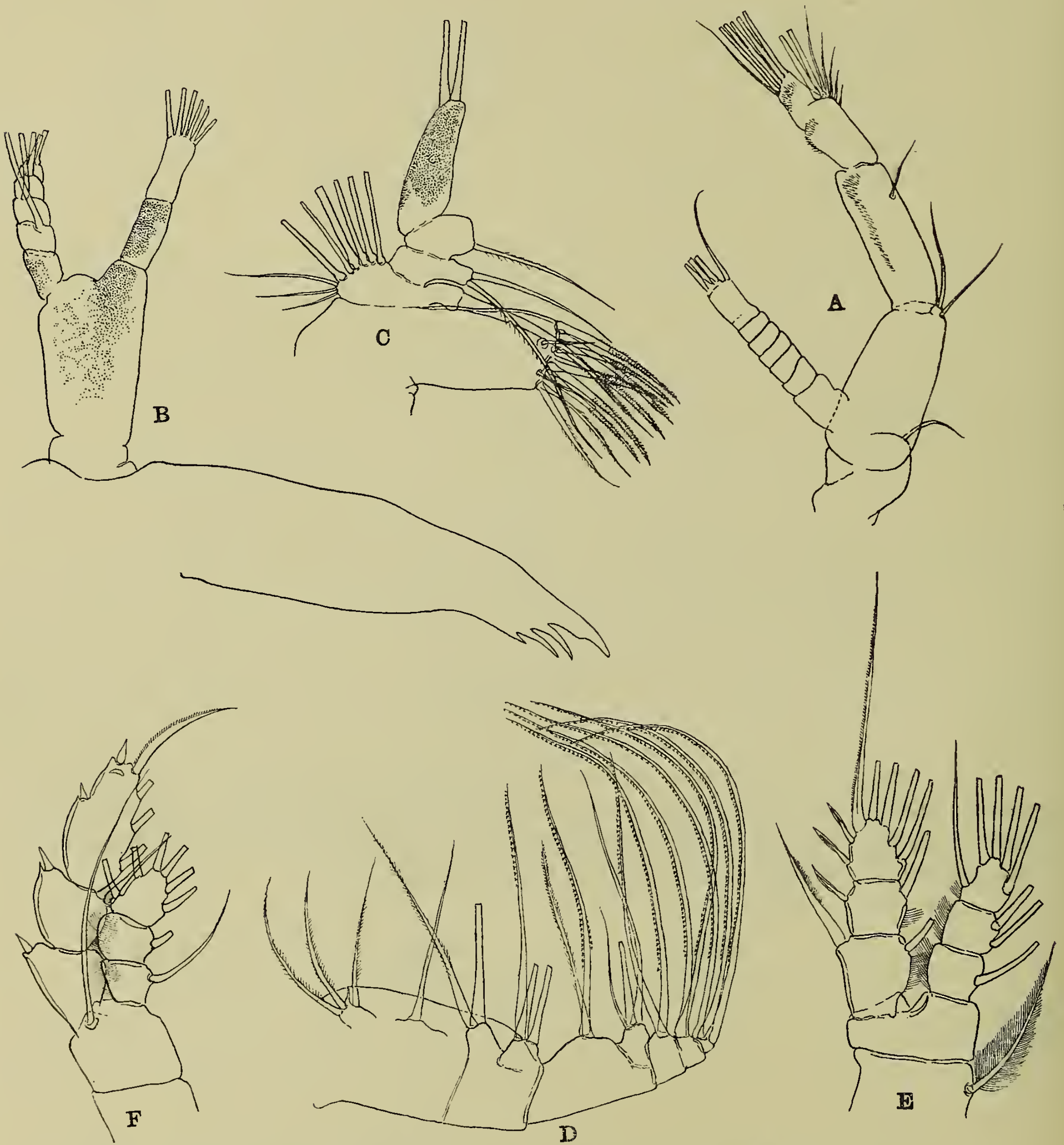
Euaugaptilus oblongus, Sars, 1925, p. 266, pl. lxxxi, figs. 1–16; Sewell, 1932, p. 322.

OCCURRENCE:

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 172, Central part of Arabian Sea, 850–0 m., 2 females.

DESCRIPTIVE NOTES.—♀. Total length, 6·15 mm.



TEXT-FIG. 58.—*Euaugaptilus oblongus* Sars, ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, 2nd maxilla. E, 1st leg. F, 5th leg.

The proportional lengths of the anterior and posterior regions of the body are as 75 to 25. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–3.	Abd. 4.	Abd. 5.	Furca.
374	134	80	77	91	107	36	52	49 = 1000

The rostrum is represented by a pair of short, stout spinous prominences. The posterior thoracic margin is bluntly rounded.

The 1st antenna overreaches the furcal rami by about the last five segments. The proportional lengths of the antennal segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	58	15	22	24	28	30	31	34	36	39	43	52	55	52	55	55	55	51

19.	20.	21.	22.	23.	24.	25.
48	36	39	35	40	39	28 = 1000

Segments 3, 9, 18, 21, 24 and 25 each bear a long seta.

In the 2nd antenna (Text-fig. 58, A) the exopod is composed of only 7 free segments, the two distal segments being fused, though a trace of the line of separation can be seen ; only the distal segment bears any setæ.

In the mandible (Text-fig. 58, B) the two rami of the palp are of approximately equal length ; the endopod bears six setæ distally. The proximal segments of both endopod and exopod, as well as the 2nd basal segment, are ornamented with numerous small fine bosses. The biting ramus is tapered and terminates in an oblique row of only four teeth, of which the 1st is stout and powerful, the 2nd and 3rd subequal and the 4th quite small.

In the 1st maxilla (Text-fig. 58, C) the biting ramus is well developed and bears 9 elongate spines, of which the anterior 7 are armed with small spinules, gradually changing to small " buttons " distally, and two other delicate, smaller setæ, which appear to be smooth. The 2nd inner lobe bears a single stout seta and the 3rd inner lobe possesses a pair of sub-equal setæ. The 2nd basal segment carries a single seta. The endopod is absent. The exopod, like the proximal segments of the exopod and endopod of the 2nd antenna, is ornamented with numerous small bosses, scattered over the surface ; it bears distally only two setæ. The outer lobe bears in all 9 setæ, of which the three proximal are small and delicate, the 4th is of moderate thickness, the 5th is slender, the 6th is long and stout, and the distal three are like the 4th.

In the 2nd maxilla (Text-fig. 58, D) the 1st lobe bears three setæ and a small pointed papilla ; the other lobes bear respectively 1, 2, 3, 2, 3 setæ ; the distal setæ are fringed with small and delicate " buttons."

In the maxilliped the distal setæ are provided with small delicate " buttons."

Distribution.—Up to the present this species has been recorded only from the North Atlantic Ocean (Sars), the Arabian Sea (present records) and the Laccadive Sea (Sewell).

Euaugaptilus tenuispinus Sars, var. (Text-fig. 59, A–F.)

Euaugaptilus tenuispinus, Sars, 1925, p. 290, pl. xcvii, figs. 1–13 ; Sewell, 1932 p. 322.

Occurrence.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female

♀. Total length, 5·30 mm.

This is rather larger than Sars' examples from the Atlantic Ocean, which measured 4·90 mm.

The proportional lengths of the segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–3.	Abd. 4.	Abd. 5.	Furca.
358	154	97	88	90	97	28	41	47 = 1000

The rostrum bears a pair of short spines directed ventrally. A small cervical groove crosses the dorsal aspect of the cephalon. The posterior thoracic margin is produced slightly backwards and is rounded. The genital aperture is not markedly prominent and is situated about the middle of the segment ; a row of fine hairs runs transversely just in front of the aperture. The 2nd furcal seta is longer and slightly thicker than the others ; its length is about twice that of the others.

The 1st antenna over-reaches the furca by about the last three segments. The proportional lengths of the segments are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
48	13	17	18	19	20	23	28	32	37	42	52	56	57	57	56	57	57

19.	20.	21.	22.	23.	24.	25.
54	46	47	43	47	44	30 = 1000

The 1st segment is partly fused with the 2nd. The segments bear long delicate setæ.

In the 2nd antenna (Text-fig. 59, A) the two rami are nearly equal in length. The endopod bears 6 setæ on the outer lobe and 3 large and 4 small setæ on the inner lobe ; these latter small setæ decrease in size from without inwards, the innermost seta being minute. The exopod is composed of eight segments ; segment 1 bears a small delicate seta, segment 2 a seta of moderate length, segments 3 to 6 each bears a long seta, segment 7 a minute seta, and segment 8, 3 large and 1 small setæ.

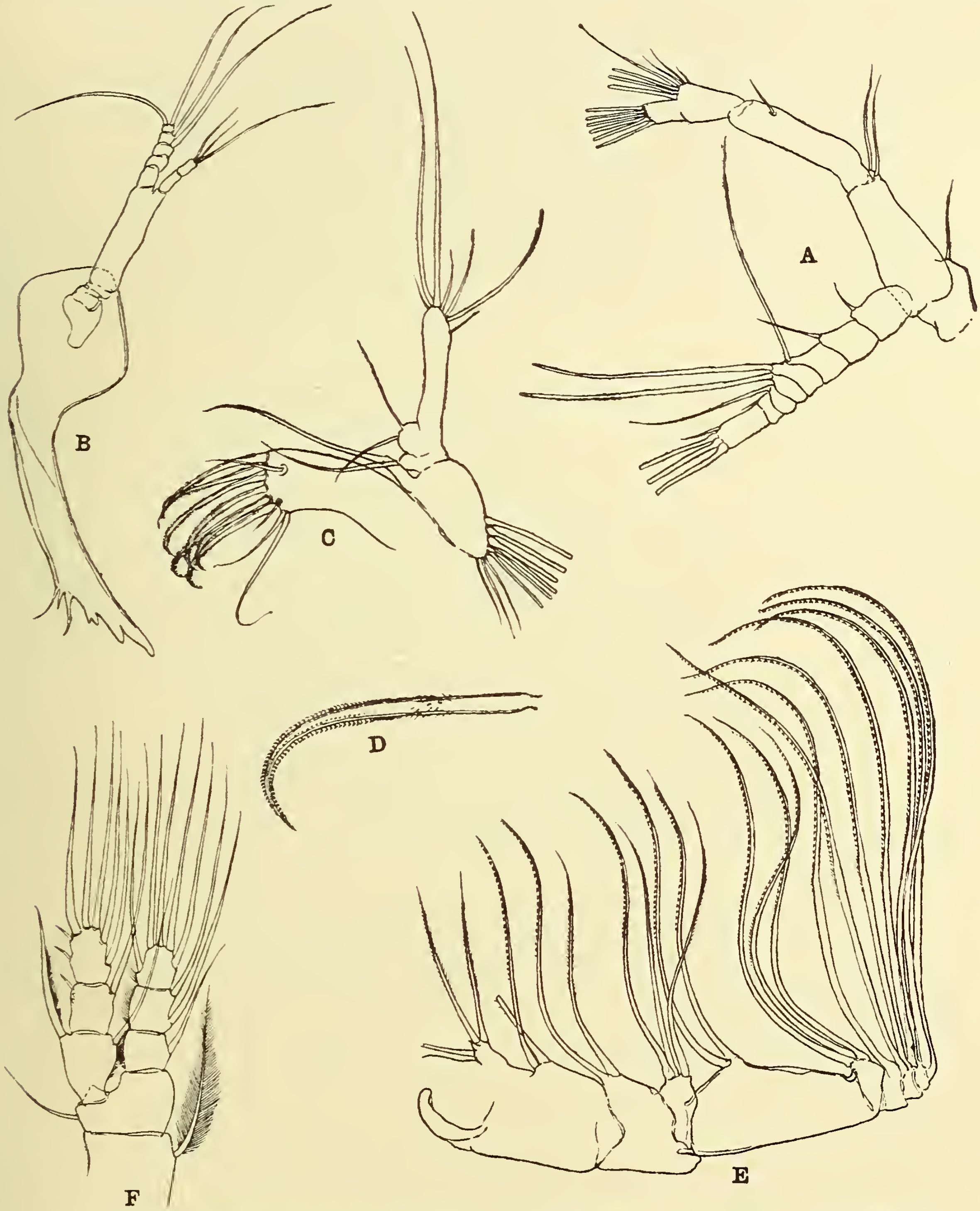
In the mandible (Text-fig. 59, B) the biting ramus is strong, but the edge is considerably more oblique than figured by Sars ; the arrangement of the teeth is, however, the same. the palp is rather small and the basal segment is slender ; the endopod reaches to about the end of the 3rd segment of the exopod and is composed of two segments, the distal bearing 3 delicate setæ. The exopod is composed of 5 segments, segments 1 and 2 are without setæ, segments 3 and 4 each bear 1, and segment 5 carries 2.

In the 1st maxilla (Text-fig. 59, C) the lobes bear the following setæ :

1st inner lobe . .	11 setæ.
2nd ,, ,, . .	1 large seta.
3rd ,, ,, . .	1 small seta.
2nd basal . . .	2 setæ.
Exopod . . .	4 setæ on the outer margin and 2 large and 1 small distally.
Outer lobe . . .	6 large and 3 small setæ.

This specimen differs from those of Sars' by having only two setæ, instead of three, on the 2nd basal segment. Seven of the setæ on the 1st inner lobe are fringed with closely set "buttons" (Text-fig. 59, D).

The 2nd maxilla (Text-fig. 59, E) is well developed and bears the following setæ on the various lobes: Lobe 1, 3, and a very short pointed process; lobe 2, 2; lobe 3, 2;



TEXT-FIG. 59.—*Euaugaptilus tenuispinus* Sars, ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, One of the biting spines of inner lobe I, enlarged. E, 2nd maxilla. F, 1st leg.

lobe 4, 3; lobe 5, 2; and lobe 6, 3; the endopod bears 7 setæ. Most of the setæ are fringed with "buttons."

The maxilliped is also well developed and bears the following setæ : lobe 1, 1 seta ; lobe 2, 3 ; lobe 3, 3 ; lobe 4, 2 ; lobe 5, 2, of which one is large ; the endopod bears on segment 1, 2 small and 2 large ; segment 2, 3 small and 1 large ; segments 3 and 4, 2 small and 1 large ; and segment 5, 1 small and 1 large ; all the large setæ on lobe 5 and the endopod are provided with " buttons."

The 1st leg (Text-fig. 59, F) agrees exactly with Sars' figure ; the marginal spine on exopod 1 is large and reaches well beyond the end of the ramus ; the marginal spines on exopod 2 and 3 are small and delicate.

The 5th leg also agrees exactly with Sars' figure.

The only real difference between this specimen and Sars' examples is the loss of one seta on the 2nd basal segment of the 1st maxilla.

Distribution.—The North Atlantic Ocean near Gibraltar, the Canary Islands and the Azores (Sars), the Arabian Sea (present record) and the Laccadive Sea (Sewell).

Group III.

Five species that I have placed in Group III are present in the collection, namely, *Euaugaptilus angustus*, *E. facilis*, *E. digitatus*, *E. longimanus* and *E. longicirrhus*. Of these, *facilis* and *digitatus* are closely related. In both the shape of the mandible is the same, and the characters of the 1st maxilla are almost identical ; and in both species there is the same tendency for the external margin of the exopod of the 2nd and 3rd swimming legs to be produced in rounded prominences at the base of the marginal spines, though this is more marked in *digitatus* than in *facilis*. *Euaugaptilus angustus* agrees with the other members of the group in that the endopod of the 1st maxilla is absent, as also is inner lobe 3, while lobe 2 is still present ; but the general shape of the biting ramus of the mandible is very similar to that of species in Group II. *E. longicirrhus* is an aberrant form, in which the mandibular palp has undergone reduction.

Euaugaptilus angustus Sars. (Text-fig. 60, E.)

Euaugaptilus angustus, Sars, 1925, p. 281, pl. xci, figs. 1–14 ; Sewell, 1932, p. 322.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Remarks.—The present specimen differs from that figured by Sars in that the 2nd basal segment of the 1st maxilla on one side bears only 2 setæ, whereas Sars (1925, pl. xci, fig. 6) shows it as having three.

A gland opens on the anterior margin of the biting ramus not far from the origin of the most anterior spine (Text-fig. 60, E).

In all other respects the present specimens agreed very closely with Sars' description and figures.

Distribution.—North Atlantic (Sars), the Arabian Sea (present records) and the Laccadive Sea (Sewell).

Euaugaptilus digitatus Sars.

Euaugaptilus digitatus, Sars, 1925, p. 275, pl. lxxxvii, figs. 1–16.

Occurrence.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

Distribution.—The North Atlantic Ocean (Sars) and the Arabian Sea (present record).

Euaugaptilus facilis (Farran).

Augaptilus facilis, Farran, 1909, p. 73, pl. iii, figs. 23, 24, pl. vii, figs. 1–6; Wolfenden, 1911, p. 343, pl. xxxviii, figs. 1, 2; text-fig. 75, *a*, *b*.
Euaugaptilus facilis, Sars, 1925, p. 273, pl. lxxxvi, figs. 1–15; Sewell, 1932, p. 322.

Occurrence.—Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Distribution.—This species has now been recorded from the region south of Davis Strait (Jespersen), the coast of Ireland (Farran), the North Atlantic Ocean (Sars), the South Atlantic (Wolfenden), the Arabian Sea (present record), the Laccadive Sea (Sewell), and the Pacific Ocean (Sars).

Euaugaptilus longimanus Sars. (Text-fig. 60, A–D; Text-fig. 61, A–J.)

Augaptilus longimanus, Wolfenden, 1911, p. 340, text-fig. 73, *a–c*.
Euaugaptilus longimanus, Sars, 1925, p. 282, pl. xcii.

Occurrence:

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female, adult.
Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 juv.
Sta. 76, Gulf of Oman, 1500–0 m., 1 juv.
Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female, juv.

Stage VI.—Adult ♀. Total length, 9·5 mm.

This is very much larger than the specimens obtained by Sars and Wolfenden in the Atlantic Ocean, which measured only 5·8 and 5·3 mm. respectively. A young ♀ in Stage V has a total length of 4·15 mm. The proportional lengths of the anterior and posterior regions of the body are as 76 to 24: Wolfenden (1911, p. 340) gives the proportions as 4·4 mm. to 0·9 mm., or 83 to 17. The proportional lengths of the various segments of the body are as follows, and for convenience of reference I have given here the proportional lengths in the immature stages:

	Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
Stage V ♂	420	134	74	70	79	48	39	32	56		48 = 1000
,, V ♀	428	123	68	68	77	89		34	56		47 = 1000
,, VI ♀	371	145	73	76	94		121		34	40	46 = 1000

The general form of the body agrees exactly with Sars' description. The genital segment is swollen ventrally and the swelling is covered with hairs. The 2nd furcal seta is about twice the length of the 4th, which is in turn about twice the length of the 1st. The accessory seta is very delicate and is about half the length of the 4th seta.

The 1st antenna overreaches the tip of the furcal ramus by about the last 5 or 6 segments. The proportional lengths of the various segments are as follows, and for reference I have given here also the lengths in the immature female and the unmodified antenna in the immature male:

Text-fig. 60.—*Euaugaptilus longimanus* Sars, adult, ♀. A, 2nd antenna. B, 1st maxilla. C, Exopod of 3rd leg. D, 5th leg. *Euaugaptilus angustus* Sars, ♀. E, 1st maxilla.

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Stage V ♀	54	10	13	14	17	18	22	22	29	33	42	54	56	58	57	54	57
,, V ♂	57	11	15	17	21	23	25	29	33	37	41	54	57	49	49	51	56
,, VI ♀	59	12	17	18	22	25	27	31	37	39	43	51	48	49	49	49	52

Segment	18.	19.	20.	21.	22.	23.	24.	25.	
Stage V ♀	56	57	41	44	50	50	53	39	= 1000
,, V ♂	57	57	47	48	45	48	42	31	= 1000
,, VI ♀	55	55	45	48	46	51	43	29	= 1000

The 1st and 2nd segments are incompletely separated, especially in the immature stages.

The 2nd antenna (Text-fig. 60. A) agrees exactly with the description and figures given by Sars. Wolfenden (1911, p. 341) states that the outer branch is much shorter than the inner. This is not strictly accurate : the outer branch is actually very slightly longer than the inner, but the latter reaches far beyond the outer ramus owing to the length of the 2nd basal segment.

In the mandible the biting ramus bears comparatively few teeth and agrees closely with the figure given by Wolfenden (1911, fig. 73 *b*). In the palp the endopod is very short and is composed of one long segment and a very short apical portion, that is only partially separated and bears two setæ : the present example thus agrees with Wolfenden's example and differs from Sars' specimen, in which there was only a single apical seta. The exopod is composed of 5 segments, of which the proximal four each bears a single seta, while the 5th segment bears 2 setæ in Stage V (♀) (Text-fig. 61, B), and only 1 in Stage VI.

The 1st maxilla (Text-fig. 60, B) differs slightly in the two stages. In Stage V the 1st inner lobe resembles that of the adult and bears only four teeth, two moderately stout and two more slender and delicate. In both stages the 2nd inner lobe is absent. The 3rd inner lobe is present in both stages ; but in Stage V it is devoid of any setæ, whereas in the adult it bears a single short stout seta. Sars appears to have overlooked this. The 2nd basal segment bears two setæ in Stage V and only one in Stage VI. The exopod on the other hand bears only 2 setæ in Stage V and 3 in Stage VI. The external lobe differs on the two sides : on the right side it bears 5 large and 1 very small setæ ; the 1st seta reaches back as far as the articulation between the 3rd and 4th thoracic segments, the 2nd seta is extremely short and very delicate, the 3rd seta also reaches back as far as the 4th thoracic segment, and the 4th, 5th and 6th are well developed, but are progressively smaller ; on the left side the 6th seta is absent. Wolfenden states that there are only 3 setæ on the outer lobe.

The 2nd maxilla, according to Sars, is " de structure toute normale " ; there is, however, a very considerable reduction in the number of setæ arising from the various lobes of the proximal segments, as follows :

Lobe 1 . .	1 large seta and 1 very small and rudimentary.
,, 2 . .	1 seta.
,, 3 . .	1 ,,
,, 4 . .	3 setæ.
,, 5 . .	2 ,,
,, 6 . .	2 ,,
Endopod . .	7 ,,

All the setæ arising from lobes 5 and 6 and from the endopod are provided with " buttons."

In the maxilliped the basal segments are long, and so is the 1st segment of the endopod, which is nearly as long as the 2nd basal segment. The number of setæ arising from the lobes of the basal segments and from the endopod are as follows :

Basal 1	Lobe 1 . .	1 seta.
	,, 2 . .	3 setæ.
	,, 3 . .	3 ,,
Basal 2	,, 4 . .	2 ,,
	,, 5 . .	2 ,,
Endopod 1	. . .	3 ,,
,, 2	. . .	2 ,,
,, 3	. . .	1 seta
,, 4	. . .	1 ,,
,, 5	. . .	1 large, 1 medium and 1 very small setæ.

With the exception of the two smaller distal setæ, all those arising from the endopod are provided with "buttons." This appendage has already attained its full development in Stage V.

The swimming legs in the main resemble those of other members of the genus ; but the 2nd segment of the endopod of the 1st leg bears only a single seta, instead of two, and the 3rd segment of the endopod of the 3rd leg has only 7, instead of 8 setæ. The setal formulæ of the two stages, V and VI, are as follows :

Stage V :

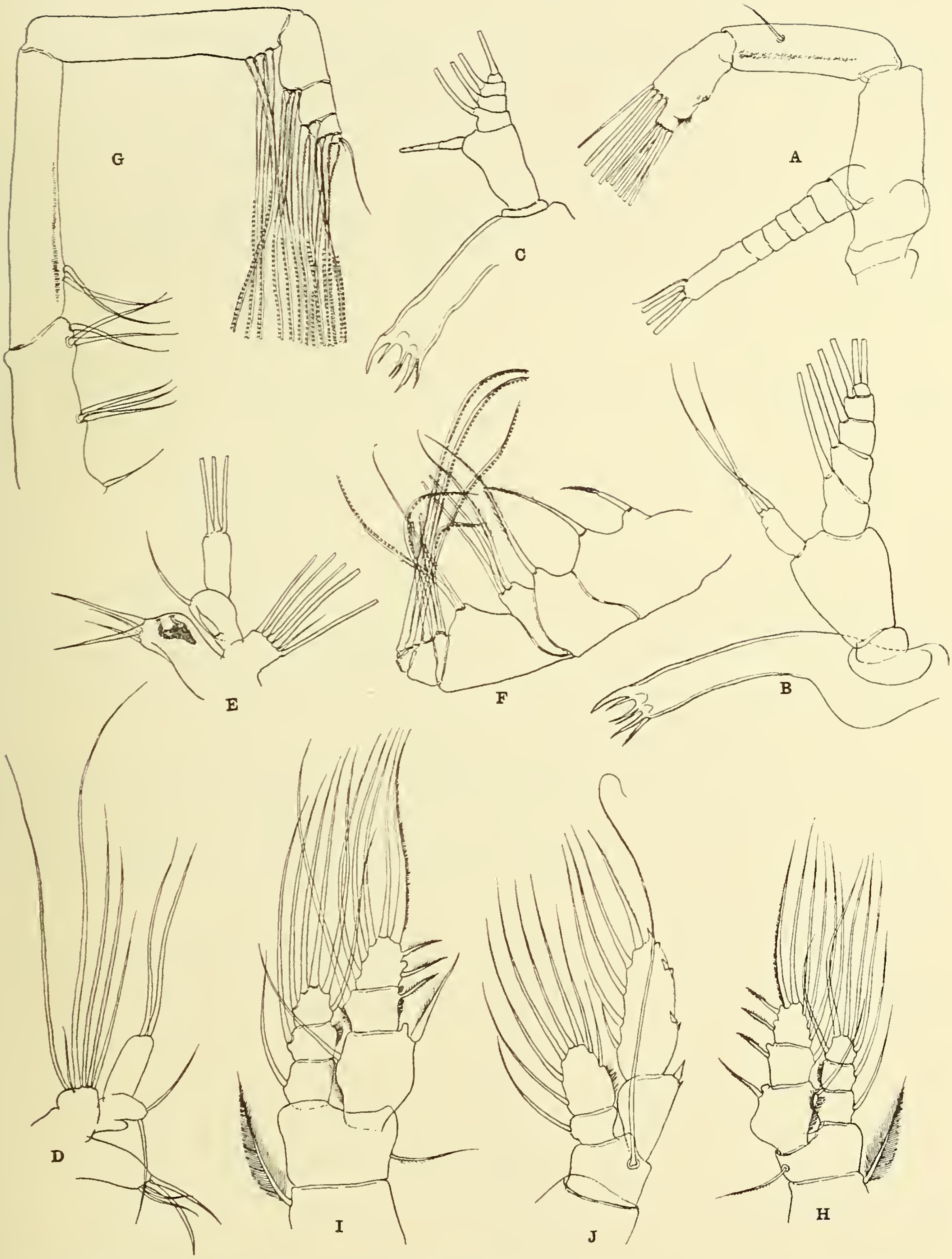
	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	1	5	1	1	4	1	1	2, 1
P. 2	1	1 or 2	7	1	1	5	1	1	3, 1
P. 3	1	2	7	1	1	5	1	1	3, 1
P. 4	1	2	7	1	1	5	1	1	3, 1
P. 5	1	$\underbrace{\quad\quad}_{7}$		0	$\underbrace{\quad\quad}_{4}$		1	$\underbrace{\quad\quad}_{3, 1}$	

Stage VI :

	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	1	5	1	1	4	1	1	2, 1
P. 2	1	2	7	1	1	5	1	1	3, 1
P. 3	1	2	7	1	1	5	1	1	3, 1
P. 4	1	2	7	1	1	5	1	1	3, 1
P. 5	1	1	6	0	1	3	1	1	2, 1

The 2nd basal segment in legs 4 and 5 of the adult each bears a long external seta, but I was unable to detect this in the young stage.

A large gland, extending the whole length of the segment, is situated in exopod 3 of the 3rd leg (Text-fig. 60, c) ; it opens to the exterior by a large pore just below the terminal spine.



TEXT-FIG. 61.—*Euaugaptilus longimanus* Sars, Stage V. A, 2nd antenna, ♂. B, Mandible, ♀. C, Mandible, ♂. D, 1st maxilla, ♀. E, 1st maxilla, ♂. F, 2nd maxilla, ♂. G, Maxilliped, ♂. H, 1st leg, ♀. I, 1st leg, ♂. J, 5th leg, ♂.

In spite of its large size, as compared with specimens from the Atlantic Ocean, there can, I think, be no doubt that this adult is a specimen of *E. longimanus* Sars.

Stage V.—♂. Total length, 8·567 mm.

The proportional lengths of the anterior and posterior regions of the body are as 78 to 22. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
420	134	74	70	79	48	39	32	56	48 = 1000

The general form of the cephalothorax agrees with that of the adult female.

The 1st antenna overreaches the tip of the furcal rami by about the last five segments. The proportional lengths of the segments differ slightly on the two sides, as will be seen from the following table :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
Right (unmodified)	57	11	15	17	21	23	25	29	33	37	41	54	57	49	49
Left (modified)	59	11	17	18	23	26	29	33	38	41	44	54	50	47	47

	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
Right (unmodified)	51	56	57	57	47	48	45	48	42	31 = 1000
Left (modified)	47	52	56	52	42	47	47	47	42	31 = 1000

The anterior margin of the 17th segment is produced in a long recumbent spine that reaches about one-third of the next segment. The 18th segment bears a horizontal spine that reaches to the end of the segment. The 19th segment bears two horizontal spines, of which the proximal reaches to a little beyond the end of the segment, while the distal reaches nearly to the end of the 20th segment.

The 2nd antenna (Text-fig. 61, A) resembles that of the adult female.

In the mandible the biting ramus resembles that of the female, but the exopod is reduced and is composed of only 4 free segments, each of which bears a single seta.

The 1st maxilla (Text-fig. 61, E) closely resembles that of Stage V of the female (Text-fig. 61, D), but in the present specimen the exopod bears three setæ instead of only two, thus resembling the adult.

The 2nd maxilla (Text-fig. 61, F) resembles that of the adult female.

The maxilliped (Text-fig. 61, G) exhibits certain differences. The numbers of setæ arising from the various lobes and segments are as follows :

Basal 1	Lobe 1 . .	1 seta.
	,, 2 . .	3 setæ.
	,, 3 . .	3 ,,
Basal 2	,, 4 . .	2 ,,
	,, 5 . .	Setæ absent.
Endopod 1 . . .		3 setæ.
,, 2 . . .		3 ,,
,, 3 . . .		2 ,,
,, 4 . . .		2 ,,
,, 5 . . .		1 large seta, 1 medium and 1 very small.

Thus lobe 5 shows a reduction in the setæ, as compared with the female, whereas endopods 3 and 4 each bear one more seta.

The 1st–4th pairs of swimming legs resemble those of the adult female.

The 5th pair of legs (Text-fig. 61, J) resembles that of the immature female, except that the 2nd basal segment bears a long seta on its posterior aspect, and I have been unable to detect any such seta in the young female.

Distribution.—This species was first recorded from the neighbourhood of the Azores and Canary Islands, in the North Atlantic Ocean (Sars), and it has since been taken in the tropical part of the South Atlantic (Wolfenden). The present records extends its distribution to the Arabian Sea and the Gulf of Oman.

? *Euaugaptilus longicirrhus* Sars. (Text-fig. 62, A–H.)

Euaugaptilus longicirrhus, Sars, 1925, p. 291, pl. cviii.

Occurrence.—Sta. 172, Central area of Arabian Sea, 850–0 m., 1 juv.

Descriptive Notes.—♀. Stage V. Total length, 3·7 mm.

The body is somewhat slender and the proportional lengths of the cephalothorax and abdomen are as 81 to 19. The proportional lengths of the various segments are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4–5.	Furca.
439	158	63	63	86	50	27	27	51	36 = 1000

The forehead is rounded and there is a small rounded rostral papilla, from which springs a pair of long, delicate setæ. The 4th and 5th thoracic segments are fused and the posterior thoracic margin is rounded. The segmentation of the abdomen has not reached its final form ; segments 1 and 2 are partially fused ventrally, but the line of demarcation is quite clear across the dorsal aspect. The furcal rami are comparatively short and bear four stout outer setæ, a slender, delicate inner seta and a short accessory seta.

The 1st antenna extends beyond the furcal rami by about the last three segments. The proportional lengths of the segments are as follows :

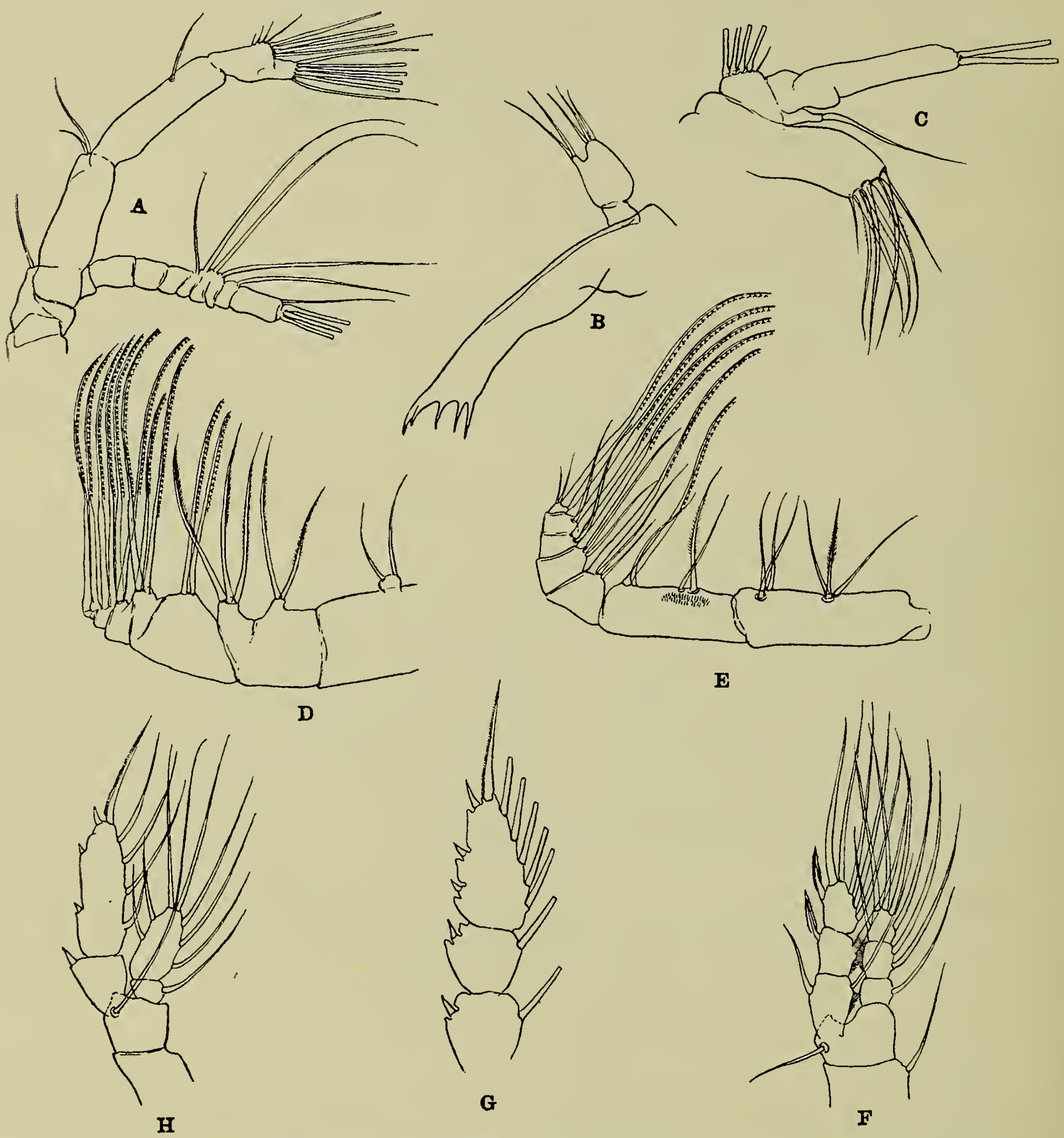
Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	66	17	21	18	22	23	24	26	26	27	33	42	50	50	50	50	57	58

19.	20.	21.	22.	23.	24.	25.
60	49	49	47	54	48	33 = 1000

In the 2nd antenna (Text-fig. 62, A) the two rami are of approximately equal length, but owing to the position of their respective origins, the exopod only reaches as far as the distal end of the 1st segment of the endopod.

The mandible (Text-fig. 62, B) possesses a long, slender biting ramus that bears a pair of stout teeth at the anterior angle ; two long delicate teeth at equal intervals, and a straight spine at the posterior angle. The palp is greatly reduced, and is composed of a short collar-like segment and an oval distal segment, that bears distally two groups of two and three setæ respectively, corresponding to the endopod and exopod. Its general character strongly resembles the appendage in *E. longicirrhus* Sars.

The 1st maxilla (Text-fig. 62, C) also closely resembles that of *E. longicirrhus*. The 1st inner lobe bears 7 long setæ, longer than the ramus itself, and an eighth, shorter and more delicate, at the posterior angle. The 2nd inner lobe bears a single stout seta. The 3rd inner lobe and the endopod are wanting. The exopod is long and bears distally two long setæ. The 1st outer lobe bears 4 long, stout setæ and a 5th small, delicate one.



TEXT-FIG. 62.—*Euaugaptilus longicirrhus* Sars (?), ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, 2nd maxilla. E, Maxilliped. F. 1st leg. G, Exopod of 3rd leg. H, 5th leg.

In the 2nd maxilla (Text-fig. 62, D) the number of setæ on the various lobes are 2, 2, 3, 2, 3. All the setæ arising from lobes 5 and 6, as well as the 7 terminal setæ, are provided with "buttons."

In the maxilliped (Text-fig. 62, E) the proportional lengths of the two basal segments

and the endopod are as 40, 31 and 29. The 1st basal segment possesses only two lobes that bear 3 setæ each. The 2nd basal bears two lobes, each supporting 2 setæ; there is a band of small needle-like spinules running along the segment beneath the proximal lobe. The segments of the endopod bear respectively 3, 3, 2, 2 and 3 setæ; those on the terminal segment are very unequal, one being long and stout and the other two very short and delicate. Six of these setæ are provided with "buttons."

In the 1st leg (Text-fig. 62, F) the rami are each composed of three segments. Segment 1 of the exopod bears a long stout seta-like spine; segments 2 and 3 each bears a single marginal spine that is well developed.

The setal formula for the first four pairs of legs is as follows:

	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	2	5	1	1	4	1	1	1, 1
P. 2	1	2	7	1	1	5	1	1	3, 1
P. 3	1	2	8	1	1	5	1	1	3, 1
P. 4	1	2	7	1	1	5	1	1	3, 1

The 5th leg (Text-fig. 62, H) is not yet fully developed, both rami being composed of only two segments; but it is clear that in the next moult the distal segment will divide into two, thus giving the full number of segments in each ramus, while the setal formula will become—

P. 5	1	1	6	0	1	3	1	1	2, 1

Remarks.—The characters of the mandible and 1st maxilla, if still present in the adult stage, would place this species in Group III B, or between this and Group IV B.

Distribution.—Up to the present time *E. longicirrhus* has been recorded only from the North Atlantic Ocean (Sars): if I am right in attributing the above example to this species, its distribution must be extended to the Arabian Sea.

Group IV.

Two species, that I refer to this group, are present in the collection, namely, *Euaugaptilus bullifer* and *E. latifrons*.

Euaugaptilus bullifer (Giesbrecht).

Augaptilus bullifer, Giesbrecht, 1892, p. 400, pl. xxviii, figs. 6, 21, 24, pl. xxxix, fig. 46.
Euaugaptilus bullifer, Sars, 1925, p. 271, pl. lxxxv, figs. 1–16.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female.

Remarks.—Giesbrecht (*loc. cit.*, p. 412) has noted the presence of rows of small spinules around the articulations of the marginal spines of the segments of the exopod of the 1st pair of legs. In this character *bullifer* differs in my experience from all other species of the genus.

Distribution.—The west coast of Ireland (Farran), the North Atlantic Ocean (Sars), the Arabian Sea (present record), the Malay Archipelago (A. Scott), and the Pacific Ocean (Giesbrecht).

Euaugaptilus latifrons Sars.

Euaugaptilus latifrons, Sars, 1925, p. 295, pl. ci, figs. 1–14; Sewell, 1932, p. 323, text-fig. 106, *a–h*.

Occurence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 1 female, juv.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Distribution.—The North Atlantic Ocean (Sars), the Arabian Sea (present records), and the Laccadive Sea (Sewell).

Genus *Augaptilus* Giesbrecht (*sensu stricto*).

Augaptilus, Giesbrecht, 1892, p. 400; Giesbrecht and Schmeil, 1898, p. 120; Sars, 1925, p. 254; Sewell, 1932, p. 315.

Augaptilus longicaudatus (Claus).

Augaptilus longicaudatus, Giesbrecht, 1892, p. 400, pl. xxvii, fig. 31, pl. xxviii, figs. 11, 19, 23, 31, 35, 38, pl. xxix, fig. 22, pl. xxxix, figs. 37, 48; Sars, 1925, p. 256, pl. lxxvi, figs. 17, 18; Esterly, 1905, p. 188, fig. 41, *a–d*.

Occurrence :

Sta. 145 D, Maldive Area, 500–0 m. vertical, 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Remarks.—Farran has called attention to the great range in size in this species. In most instances the total length is about 3·5–4·3 mm. in the female; the present examples had a length of 3·667 mm. Off the Irish coast Farran obtained examples as large as 4·5–5·9 mm. which showed certain differences in the number of setæ on the terminal segments of the 2nd maxilliped. As no other points of difference were detected, he did not consider that these large forms could be regarded as a separate species.

Distribution.—The coast of Ireland (Farran), the North Atlantic (Sars, Lysholm and Nordgaard), the Mediterranean Sea (Claus, Pesta, Rose), the Gulf of Guinea (T. Scott), the South Atlantic Ocean (Wolfenden), the Arabian Sea and Maldive area (present records) the Malay Archipelago (A. Scott), the Australian Barrier Reefs (Farran), off New Zealand (Farran), the central area of the Pacific Ocean (Giesbrecht), and the San Diego region of the coast of California (Esterly).

Genus *Centraugaptilus* Sars.

Centraugaptilus, Sars, 1925, p. 304.

Centraugaptilus horridus (Farran).

Augaptilus horridus, Farran, 1909, p. 78, pl. viii, fig. 20.
Centraugaptilus horridus, Sars, 1925, p. 307, pl. cvii, figs. 11–18; Sewell, 1932, p. 326, text-fig. 107, *a–g*.
Augaptilus pyramidalis, Esterly, 1911, p. 334, pl. xxvi, figs. 1, 9; pl. xxx, fig. 69; pl. xxxii, fig. 106.

OCCURRENCE :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 2 females ; 1500–0 m., 1 female.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 76, Gulf of Oman, 1500–0 m., 3 females.

REMARKS.—This species appears to exhibit a considerable variation in size. Farran's original example measures as much as 10 mm., and those of Sars from the North Atlantic 9·6 mm. Jespersen (1934, p. 114) gives the length of his example as only 7·5 mm. Esterly's specimen from the Pacific measured 6·68 mm. The male, taken by me in the Bay of Bengal, measured 8·4 mm., but the present females range from 6 to 7 mm. in length.

DISTRIBUTION.—South-west of Iceland (Jespersen), the west coast of Ireland (Farran), the North Atlantic Ocean near the Canary Islands and the Azores (Sars), the Arabian Sea and Gulf of Oman (present records), the Bay of Bengal (Sewell) and the east Pacific Ocean, San Diego region (Esterly, as *Augaptilus pyramidalis*).

Family ARIETELLIDÆ.

Genus *Arietellus* Giesbrecht.

Arietellus, Giesbrecht, 1892, p. 415 ; Giesbrecht and Schmeil, 1898, p. 124.

Arietellus giesbrechti Sars. (Text-fig. 63, A–M.)

Arietellus giesbrechti, Sars, 1925, p. 331, pl. cxix, figs. 1–6.
Arietellus sp., Farran, 1906, p. 82.

OCCURRENCE :

Sta. 131 D, Southern area of Arabian Sea, 500–0 m. vertical, 1 female.

Sta. 172, Central area of Arabian Sea, 200–0 m., 2 females ; 400–0 m., 1 male.

DESCRIPTIVE NOTES.—♀. Total length, 5·16 and 5·53 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
382	140	94	89	65	72	37	33	37	51 = 1000

The cephalothorax is an elongate oval, tapering somewhat anteriorly but not so markedly as in *A. setosus* or *A. aculeatus*. The forehead terminates anteriorly in a very small pointed process directed forwards and slightly downwards. The posterior thoracic margins extend backwards in a broad flap, which is produced at its apex in a spinous process that, viewed from the dorsal aspect, curves slightly inwards, and when seen from the side curves slightly upwards. The two sides appear to be symmetrical. The genital segment of the abdomen is as broad as long and is abruptly narrowed about half-way back. The furcal rami are nearly as broad as long and are densely haired on both inner and outer margins. In this respect the present specimens agree closely with Sars' description and figures of *A. giesbrechti*. Of the furcal setæ the 2nd is nearly twice the length of the others and is only sparsely haired ; the 1st, 3rd, 4th and 5th setæ are all of approximately equal length and are very densely haired. The accessory seta is about half the length of the 1st seta, and, like the 2nd, is sparsely haired. The furcal setæ are of a dark auburn tint, shot with blue. The body is plentifully supplied with cutaneous glands, which are particularly

numerous in the postero-lateral region of the fused 4th–5th thoracic segments (Text-fig. 63, A). In the lateral region of the 1st thoracic segment near the posterior margin lie 2 or 3 apertures ; in the corresponding region of the 2nd thoracic segment is a group of 6 ; in the 3rd segment there is a group of 25 or 26 ; and on segments 4–5 the number has increased to over 100. A pair of pores is present in the dorso-lateral region of the anal segment, and 3 open on the dorsal aspect of the furcal ramus.

The 1st antenna (Text-fig. 63, B) reaches back to about the posterior margin of the thorax. The proportional lengths of the several segments are as follows :

Segment	1–2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12–13.	14.	15.	16.	17.	18.
	178	43	21	19	15	15	10	9	9	11	53	48	62	80	91	86

19.	20.	21–25.	
94	75	81	= 1000

Segments 1 and 2 are completely fused ; segments 8, 9 and 10 are partly fused ; segments 12 and 13 are also almost completely fused, and segments 21 to 25 are completely fused, and the surface of the combined segment is covered with very fine punctations.

The 2nd antenna (Text-fig. 63, C) and mouth parts (Text-fig. 63, D, E, G and H) agree closely with the appendages of *A. setosus ;* in the 1st maxilla the endopod is represented by a small, rounded swelling.

The setal formula of the swimming legs is as follows :

	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	2	5	1	1	4	1	1	2, 1
P. 2	1	2	8	1	1	5	1	1	3, 1
P. 3	1	2	8	1	1	5	1	1	3, 1
P. 4	1	2	7	1	1	5	1	1	3, 1

The 5th pair of legs have the characteristic form of the genus (Text-fig. 63, L).

♂. Total length, 4·67 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.	
381	143	88	85	64	51	31	31	28	37	61	= 1000

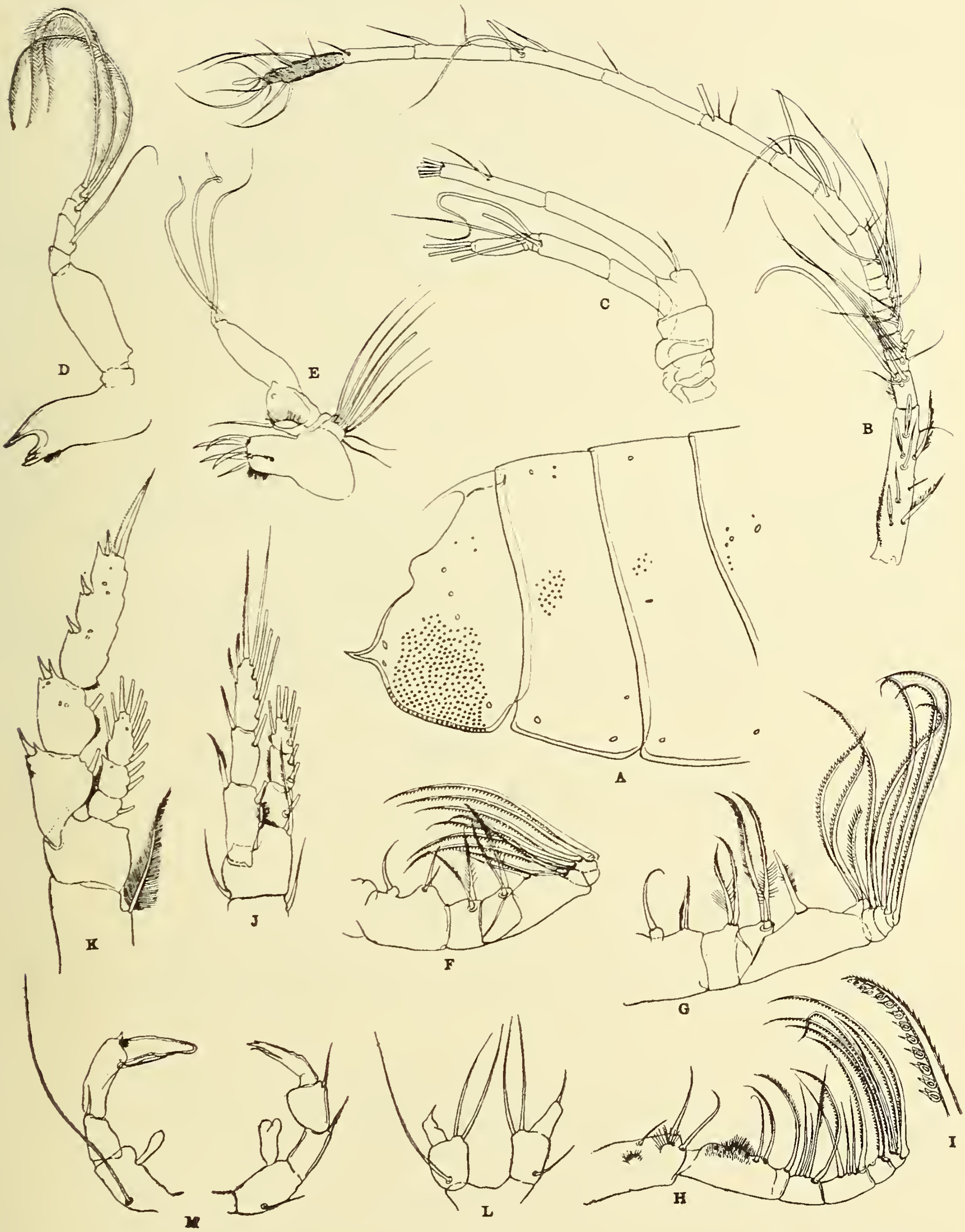
The general shape of the body resembles that of the female.

The left 1st antenna is modified to form a grasping organ, the segments of which have the following proportional lengths :

Segment	1–2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
	177	47	22	20	15	15	10	12	9	12	13	49	57	70	91	98	91

19–20.	21–25.	
141	51	= 1000

The distal half of the fused 19–20 segment and the whole of the 21–25 segment are finely punctate. The structure of the antennæ and mouth parts appears to be identical with



TEXT-FIG. 63.—*Arietellus giesbrechti* Sars, A, Posterior thoracic segments, lateral view. B, 1st antenna, ♀. C, 2nd antenna, ♀. D, Mandible, ♀. E, 1st maxilla, ♀. F, 2nd maxilla, ♂. G, 2nd maxilla, ♀. H, Maxilliped, ♀. I, One of the spines, enlarged. J, 1st leg. K, 3rd leg. L, 5th pair of legs, ♀. M, 5th pair of legs, ♂.

those of *A. setosus*. The strong setæ arising from the distal portion of both the 2nd maxilla and the maxilliped bear a row of flattened platelets each terminating in a short spine, as figured by Esterly in *A. setosus* (*vide* Esterly, 1905, fig. 42, *c*).

The swimming legs resemble those of the female.

The 5th pair of legs (Text-fig. 63, M) appear to resemble those of *A. plumifer* Sars more nearly than the figure given by Sars for *A. giesbrechti*.

Distribution.—Sars described this species from the temperate region of the North Atlantic Ocean. Subsequently Farran (1906, p. 82) obtained a few specimens of a species that, while resembling *A. giesbrechti* rather closely, showed no signs of asymmetry in the body. It seems probable that the present specimens are conspecific with those obtained by Farran off the west coast of Ireland, and if these are examples of *A. giesbrechti*, the species occurs in the Arabian Sea.

Arietellus plumifer Sars.

Arietellus plumifer, Sars, 1925, p. 332, pl. cxix, figs. 7–11.

Occurrence.—Sta. 96, Central part of Arabian Sea, 645–400 m., 1 female, 2 males, juv.

Remarks.—These examples agreed exactly with Sars' description so far as the general shape of the body, the character of the furcal rami and the proportional lengths of the furcal setæ and their dense feathering are concerned.

Distribution.—Originally described by Sars from the North Atlantic Ocean between Portugal and the Azores and Canary Islands, the species has since been taken by Farran off the west coast of Ireland, and by Lysholm and Nordgaard in the North Atlantic as far as 60° N. lat. The present record extends its distribution to the Arabian Sea.

Arietellus simplex Sars.

Arietellus simplex, Sars, 1925, p. 334, pl. cxx, figs. 7–12.
Arietellus major, Esterly, 1906, p. 74, pl. ix, fig. 17, pl. xi, figs. 43, 44, pl. xii, fig. 56, pl. xiii, fig. 80.

Occurrence:

Sta. 96, Central area of Arabian Sea, 645–400 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Distribution.—The San Diego region of the Californian coast (Esterly), the Malay Archipelago (A. Scott), the Laccadive Sea (Sewell), the Arabian Sea (present records), the tropical Atlantic Ocean (Wolfenden), near the Azores (Sars), and off the west coast of Ireland (Farran).

Genus *Phyllopus* Brady.

Phyllopus, Brady, 1883, p. 78; Giesbrecht and Schmeil, 1898, p. 124.

Phyllopus impar Farran.

Phyllopus impar, Farran, 1908, p. 84, pl. ix, figs. 1–4; A. Scott, 1909, p. 149, pl. xlv, figs. 10–18; Sars, 1925, p. 340, pl. cxxiii, figs. 1–17.

Occurrence.—Sta. 76, Gulf of Oman, 1500–0 m., 1 female.

Distribution.—South of Iceland in 60° N. lat. (Lysholm and Nordgaard), the west

coast of Ireland (Farran), off Gibraltar and near the Azores (Sars), the tropical Atlantic (Wolfenden), the Gulf of Guinea (T. Scott, as *P. bidentatus*), the Gulf of Oman (present record) and the Malay Archipelago (A. Scott).

Phyllopus muticus Sars. (Text-fig. 64, A–J.)

Phyllopus muticus, Sars, 1925, p. 345, pl. cxxiv, figs. 10–16.

Occurrence.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 male.

Descriptive Notes.—♂. Total length, 5·03 mm. This is slightly larger than the females described by Sars, which measured 4·80 mm. The proportional lengths of the cephalothorax and abdomen are as 63 to 37. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
290	113	68	68	100	65	64	61	55	55	61 = 1000

Viewed from above the forehead is somewhat truncated and the posterior margins of the 5th thoracic segment are also truncated. The furcal rami and furcal setæ agree exactly with Sars' description, the 2nd furcal seta on the left side being about half as long again as the other setæ, and the corresponding seta on the right side as much as two-and-a-half times their length.

The body is plentifully provided with the openings of numerous cutaneous glands, that appear to be of two kinds : first, comparatively large multicellular glands that open by large apertures, and second, small glands composed of only one or two cells, that open by small pores. The distribution of these glands and their apertures is shown in Text-fig. 64, A.

The 1st antenna is comparatively short, not reaching as far as the posterior thoracic margin. The proportional lengths of the segments in the two appendages are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Right	80	23	24	25	32	32	27	23	23	20	22	24	36	42	51	60	61	64
Left	112		33	33	37	38	34	22	26	20	22	25	21	59	64	75	73	62

19.	20.	21.	22.	23.	24–25.
64	57	51	47	50	62 = 1000
90		92			62 = 1000

In the stained specimen the 1st segment on the right side clearly shows traces of segmentation into three portions. In the left grasping antenna (Text-fig. 64, B) the 1st and 2nd segments are fused together ; beyond the hinge-joint there are three separate joints, the first composed of the fused 19th and 20th segments, the second of the fused 21st–23rd segments and the terminal portion of the fused 24th–25th segments respectively.

The 2nd antenna (Text-fig. 64, D) closely resembles that of *P. impar* Farran. A gland opens on the inner side of the 2nd basal segment near the origin of the marginal setæ ; and a smaller aperture is situated about the middle of the length of the 1st segment of the endopod opposite the origin of the two marginal setæ arising from that segment.

In the mandible (Text-fig. 64, E) the biting ramus agrees exactly with that of the female, as figured by Sars.

TEXT-FIG. 64.—*Phyllopus muticus* Sars, ♂. A, Lateral view. B, 1st antenna, left side. C, Proximal segments of 1st antenna, right side. D, 2nd antenna. E, Mandible. F, 1st maxilla. G, 2nd maxilla. H, 1st leg. I, 3rd leg. J, 5th pair of legs.

The maxillæ (Text-fig. 64, F, G) and maxillipeds agree with those of the female.

The 1st swimming leg (Text-fig. 64, H) closely resembles that of *Phyllopus bidentatus* Brady, as figured by Giesbrecht (1892, pl. xviii, fig. 30). A gland opens on the 3rd segment

of the exopod near the origin of the 1st marginal spine, and a similar gland opens on the 3rd segment of the endopod.

The 2nd, 3rd (Text-fig. 64, I) and 4th swimming legs are plentifully supplied with glands.

The 5th pair of legs (Text-fig. 64, J) has the same general character as the males of other species, but differs in details that are best seen in the figure.

DISTRIBUTION.—This species was described by Sars from the female that was taken in the North Atlantic Ocean near the Canary Islands. The occurrence of what I take to be the male in the present collection indicates that its range probably extends to the Arabian Sea.

Genus *Pachyptilus* Sars.

Pachyptilus, Sars, 1925, p. 318.

Pachyptilus eurygnathus Sars. (Text-fig. 65, A–F.)

Pachyptilus eurygnathus, Sars, 1925, p. 321, pl. cxiv, figs. 1–13.

OCCURRENCE :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 1 female ; 1500–0 m., 2 females.

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 6 females.

Sta. 76, Gulf of Oman, 1500–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

REMARKS.—With the exception of one single feature all the above specimens agree with the description and figures given by Sars : this feature is the character of the endopod of the 1st pair of legs. Sars (*loc. cit.*, pl. cxiv, fig. 10) shows this ramus as consisting of three segments, whereas in the present specimens there are only two segments, as in *P. lobatus*.

DISTRIBUTION.—Up to the present time this species has been recorded solely from the North Atlantic Ocean (Sars) and the Arabian Sea and Gulf of Oman (present records).

Pachyptilus lobatus Sars.

Pachyptilus lobatus, Sars, 1925, p. 322, pl. cxv, figs. 1–14.

OCCURRENCE.—Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.

REMARKS.—This single specimen appears to agree exactly with the description and figures given by Sars.

DISTRIBUTION.—Hitherto known only from the temperate region of the North Atlantic Ocean (Sars), the present record extends the distribution to the Arabian Sea.

Genus *Heteroptilus* Sars.

Heteroptilus, Sars, 1925, p. 324.

Heteroptilus acutilobus Sars. (Text-fig. 66, A–H.)

Heteroptilus acutilobus, Sars, 1925, p. 326, pl. cxvii, figs. 1–15.

TEXT-FIG. 65.—*Pachyptilus eurygnathus* Sars, ♀. A, 2nd antenna. B, Mandible. C, 1st maxilla. D, Maxilliped. E, 1st leg. F, 5th leg.

Occurrence.—Sta. 186, Gulf of Aden, 575–0 m., 2 females.

Descriptive Notes.—♀. Total length, 4·517 mm.

The proportional lengths of the cephalothorax and abdomen are as 73 to 27. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
391	111	74	74	85	96	44	33	18	74 = 1000

The cephalon and 1st thoracic segment are separate. The forehead is rounded, and ventrally the head is produced in a downwardly directed curved prominence, the margin of which is irregularly crenated. There are no rostral filaments. The posterior thoracic margin is produced backwards in the lateral region in a sharp straight spine. The genital segment is produced ventrally in a well-marked eminence at about the middle of its length. The anal segment is short. The furcal rami are long and are about twice as long as broad ; they are truncated distally and from this part arise four setæ, the 5th arising from the outer margin a little beyond the middle of the length of the ramus.

The 1st antenna reaches to the tip of the furcal ramus.

The proportional lengths of the various segments are as follows :

Segment 1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
87	18	18	18	22	20	20	20	22	25	29	32	54	55	58	59	59	57

19.	20.	21.	22.	23.	24.	25.
59	46	45	41	53	64	19 = 1000

The segments are provided with numerous long filaments.

In the 2nd antenna (Text-fig. 66, A) the exopod is considerably longer than the endopod in the proportion of 54 to 46. The exopod is composed of eight segments ; the 1st and 2nd segments each bear a rather short delicate seta, but the setæ arising from the more distal segments are stouter and much longer.

The mandibles of the two sides differ ; on the right side (Text-fig. 66, B) a long curved tooth projects forward from the anterior margin, and the right paragnath is equally produced in a corresponding long fleshy lobe. The 2nd basal segment bears a long seta on the inner margin.

The 1st maxilla (Text-fig. 66, C) agrees with Sars' description and figures and the 2nd outer lobe bears a moderately stout seta.

The other appendages agree closely with the description and figures given by Sars.

The setal formula of the swimming legs is as follows :

	Endopod.			Exopod. Inner.			Exopod. Outer.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.
P. 1	1	6		1	1	4	1	1	2, 1
P. 2	1	2	7	1	1	5	1	1	3, 1
P. 3	1	2	7	1	1	5	1	1	3, 1
P. 4	1	2	6	1	1	5	1	1	3, 1
P. 5	4			0	1	3	1	1	2, 1

I have no hesitation in referring this example to Sars' species.

TEXT-FIG. 66.—*Heteroptilus acutilobus* Sars, ♀. A, 2nd antenna. B, Right mandible. C, 1st maxilla. D, 2nd maxilla. E, Maxilliped. F, 1st leg. G, 3rd leg. H, 5th leg.

Distribution.—The Bay of Biscay (Farran), the temperate region of the North Atlantic Ocean (Sars) and the Gulf of Aden (present record).

Heteroptilus sp. (Text-fig. 67, A–J.)

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 male.

Descriptive Notes.—♂. Total length, 6·55 mm.

The proportional lengths of the cephalothorax and abdomen are as 75 to 25. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4–5.	Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
394	115	71	71	99	51	41	38	33	18	69 = 1000

The anterior region of the cephalon is similar to that of the female described above. The posterior thoracic margin of the 5th segment is produced backwards in a wing, the apex of which is rounded and bears a minute hair or seta.

The left 1st antenna (Text-fig. 67, A) is modified into a grasping organ. The proportional lengths of the various segments are as follows :

Segment	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Right	78	12	15	15	17	17	17	17	19	22	27	32	52	54	54	59	63	65
Left	78	12	14	14	17	17	17	19	22	25	29	34	48	59	59	60	65	70

19.	20.	21.	22.	23.	24.	25.
65	52	52	52	56	73	15 = 1000
	140		113		72	16 = 1000

In the grasping antenna the middle segments are only very slightly, if at all, increased in size ; the 17th segment is produced in a straight horizontal spine that overhangs the 18th segment. Segments 19 to 21 are fused together and the combined joint bears two straight spines, of which the distal is the longer. Segments 22 and 23 are fused, and 24 and 25 separate.

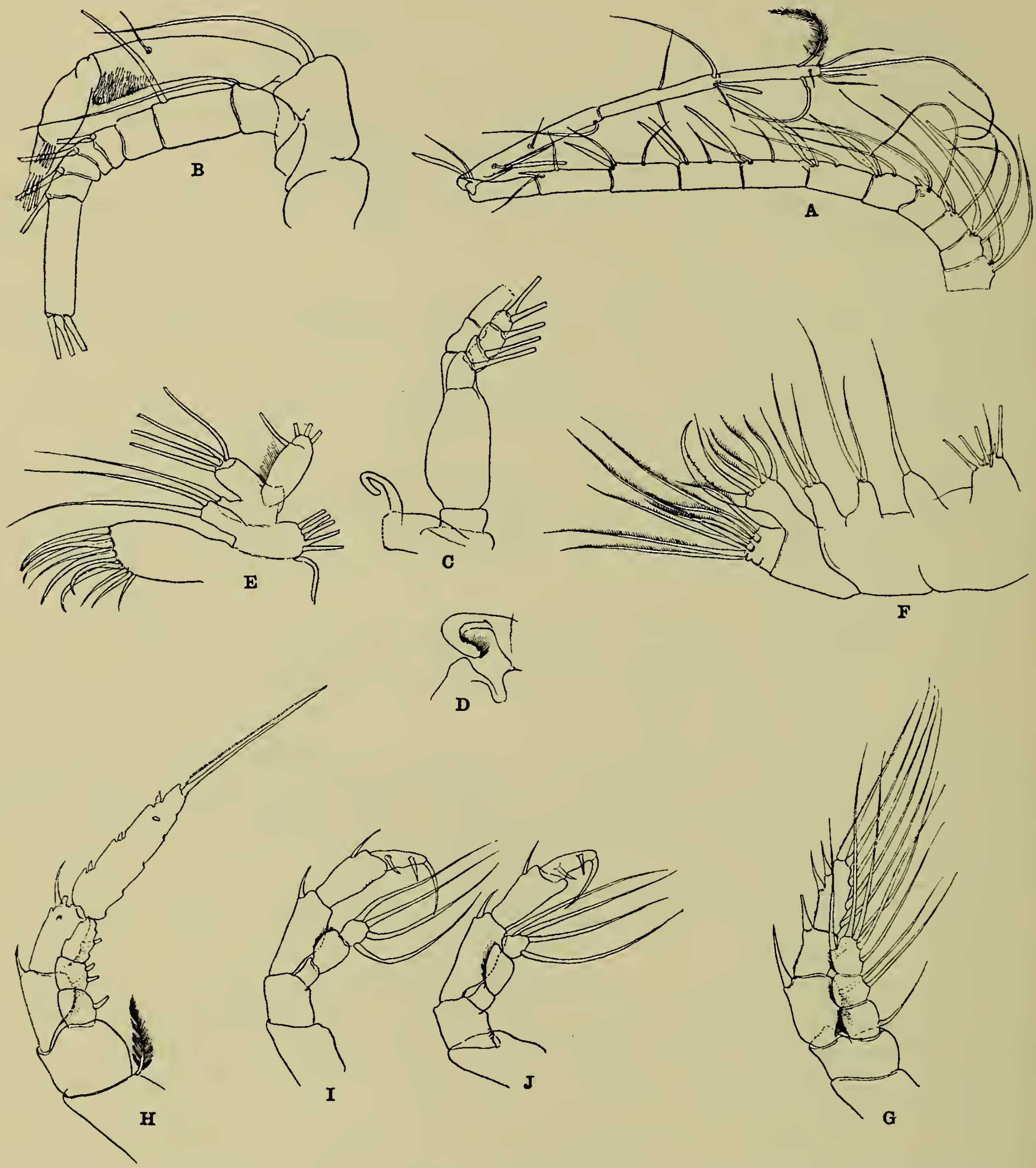
In the 2nd antenna (Text-fig. 67, B) the proportional lengths of the exopod and endopod are as 53 to 47.

The mandibles are asymmetrical. On the right side (Text-fig. 67, C) the biting ramus is produced on its anterior aspect in a long curved tooth, similar to that in the female *H. attenuatus* ; in association with this tooth there is a curved tongue-like process from the lateral lip of the mouth on the right side (Text-fig. 67, D). Sars (1925, p. 325, pl. cxvi, fig. 8) has described and figured a similar projection in *H. attenuatus*, but he states that it is situated on the *left* side ; this, I think, must be an error, for it seems to me that the hook-like tooth on the mandible and the palp-like process are in apposition with each other.

In the left mandible the biting ramus bears a series of five teeth and a seta ; the 1st tooth is simple ; the 2nd is bifid but has a straight posterior margin ; the 3rd, 4th and 5th are bifid at their extremities and their posterior edges are armed with a row of spines. The basal segment of the palp bears a seta : the endopod arises from the segment considerably distal to the origin of the exopod, as in *Heteroptilus acutilobatus*.

The 1st maxilla (Text-fig. 67, E) closely resembles that of the female, described above, except that the seta arising from the 2nd outer lobe is small.

In the 2nd maxilla (Text-fig. 67, F), the 1st lobe bears two groups of setæ; in the



TEXT-FIG. 67.—*Heteroptilus* sp., ♂. A, 1st antenna of left side. B, 2nd antenna. C, Mandibular palp and base of biting ramus of right side. D, Curved process on posterior lip of mouth. E, 1st maxilla. F, 2nd maxilla. G, 1st leg. H. 3rd leg. I, Right 5th leg. J, Left 5th leg.

1st group are two setæ, the distal of which is minute; in the 2nd group are 4 setæ, of which the 1st is much smaller than the others. The 2nd lobe bears a single seta. The 3rd lobe has 2, and the 4th lobe, 3 setæ. The 5th lobe bears 6 setæ, of which four are

serrated, and the 6th is a stout curved spine with a few teeth on its margin. The 1st and 2nd segments of the endopod bear two setæ, one short and curved and the other straight: both are serrated along one margin. The 3rd segment bears 3 straight, serrated setæ.

The maxilliped appears to resemble that of *H. acutilobus*.

In the 1st swimming leg (Text-fig. 67, G) the endopod consists of three segments, whereas in the females of both *H. attenuatus* and *H. acutilobus* there are only two. Unfortunately Sars neither describes nor figures the 1st leg in the male of *H. acutilobus*, but, as he makes no mention of any difference, it is to be presumed that in that species the endopod resembles that of the female and is composed of two segments only.

The 2nd, 3rd and 4th legs are normal in structure, both rami being composed of three segments. The 3rd segment of the exopod shows a slight difference from the condition seen in *H. acutilobus* ♀. The distal marginal spine, instead of being situated at the external distal angle, arises from the outer margin at a point about $\frac{4}{5}$ths the length of the segment. The external marginal spines arising from exopod 1 and 2 are much longer than in *H. acutilobus* ♀.

The 5th pair of legs is symmetrical (Text-fig. 67, I and J). The exopod is composed of three segments, of which the 1st and 2nd each bear a single marginal spine and the 3rd segment bears two marginal spines and a terminal spine. There are no setæ on the inner margin of any of the segments. The endopod is composed of three segments, of which the 1st and 2nd are devoid of a seta and the 3rd segment bears 4 setæ.

In its general appearance this specimen somewhat resembles the female of *H. attenuatus* Sars and may perhaps be the unknown male of that species, but, as the number of segments in the swimming legs differs, I cannot definitely refer it to that species.

Distribution.—The Arabian Sea (present record).

Family Candacidæ.

Genus *Candacia* Dana.

Candacia, Giesbrecht, 1892, p. 423; Giesbrecht and Schmeil, 1898, p. 126.

Candacia æthiopica (Dana).

Candacia ethiopica, Giesbrecht, 1892, p. 424, pl. iv, fig. 13, pl. xxi, figs. 1, 9, pl. xxii, figs. 1, 6, 13, 14, 32, 40, pl. xxix, figs. 7, 11, 13.
Candacia aethiopica, Esterly, 1905, p. 196, fig. 47 *a–h*.

Occurrence:

Sta. 61 C, Northern area of Arabian Sea, surface, 120 specimens.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female; 1500–0 m., 1 female.

Sta. 145 C, Maldive area, 50–0 m. vertical, 1 female, 1 male.

Sta. 145 D, Maldive area, 50–0 m., vertical, 1 female.

Distribution.—The San Diego region of the Californian coast (Esterly), the Pacific Ocean (Dana, Giesbrecht, Streets), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), the coast of S. Burma (Sewell), the Bay of Bengal (Thompson, Cleve), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Laccadive Sea and Arabian Sea (Thompson and A. Scott, A. Scott, present

records), the Red Sea (Thompson and A. Scott), the South Atlantic Ocean, west of Cape Colony (Wolfenden), the south temperate Atlantic (Farran), tropical North Atlantic Ocean (Giesbrecht, Wolfenden), the temperate North Atlantic Ocean (T. Scott, Farran, Sars, Rose) and the Mediterranean Sea (Claus, Pesta, Rose).

Candacia bipinnata Giesbrecht.

Candacia bipinnata, Giesbrecht, 1892, p. 424, pl. xxii, fig. 20, pl. xxxix, figs. 27, 29; Esterly, 1905, p. 195, fig. 45, *a–c*; Rose, 1929, p. 40, pl. ii, fig. 6, pl. iii, fig. 6.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 4 females; 1500–0 m., 2 females.

Distribution.—The San Diego region of the Californian coast (Esterly), the western Pacific Ocean between 29° N. and 3° S. (Giesbrecht), off New Zealand (Farran), the south-east part of the Indian Ocean, Abrolhos Islands (Giesbrecht), the southern area of the Arabian Sea (present record), off South Africa (T. Scott, Cleve), the tropical South Atlantic Ocean off Rio de Janeiro (Farran), the north temperate Atlantic Ocean (Farran) and the western part of the Mediterranean Sea (Rose).

Candacia bispinosa (Claus).

Candacia bispinosa, Giesbrecht, 1892, p. 424, pl. xxi, figs. 6, 7, 16, 27, pl. xxii, figs. 4, 8, 22, 33, 35, 38, 39, pl. xxxix, figs. 15–17, 20.

Occurrence.—Sta. 145 C, Maldive area, 50–0 m., vertical, 1 female.

Distribution.—The Pacific Ocean between 16° and 20° N. (Giesbrecht), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), the Bay of Bengal (Sewell), the Maldive area (present record), the Gulf of Aden (A. Scott), the Red Sea (Thompson and A. Scott), the South-west part of the Indian Ocean (Wolfenden), the South Atlantic Ocean (T. Scott, Wolfenden), Tropical Atlantic (Wolfenden, Farran), temperate North Atlantic Ocean (T. Scott, Farran, Sars), and the Mediterranean Sea (Claus, Thompson, Thompson and A. Scott, A. Scott, Sars, Pesta, Rose).

Candacia curta (Dana).

Candacia curta, Giesbrecht, 1892, p. 424, pl. xxi, fig. 15, pl. xxii, figs. 2, 24, pl. xxxix, figs. 8–10, 12; Esterly, 1905, p. 196, fig. 46, *a–c*.

Occurrence:

Sta. 61 C, Southern area of Arabian Sea, surface, 120 specimens.
Sta. 76, Gulf of Oman, 200–0 m., 4 females; 1500–0 m., 2 females.
Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female, 1 male.
Sta. 172, Central area of Arabian Sea, 200–0 m., 1 male.

Distribution.—The San Diego region of the Californian coast (Esterly), the west coast of South America to 50° S. (Giesbrecht, Dana), the eastern Pacific (Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott), the Arabian Sea and Gulf of Oman (Thompson and A. Scott, Cleve, present records), the Gulf of Aden (Thompson and A. Scott), the Red Sea (Giesbrecht, Cleve, Thompson and A. Scott), east of Cape Colony (Cleve), the Gulf of Guinea (T. Scott. as *C. intermedia*),

the South Atlantic Ocean (Giesbrecht, Wolfenden), and the tropical region of the Atlantic Ocean (T. Scott, Farran).

Candacia longimana Claus.

Candacia longimana, Giesbrecht, 1892, p. 424, pl. xxi, figs. 5, 18, pl. xxii, figs. 5, 7, 15, 26, 34, 36, pl. xxxix, figs. 4–6, 18, 19.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 3 males.

Distribution.—The western Pacific Ocean (Giesbrecht), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), the Arabian Sea (Thompson, present record), the Gulf of Aden and Red Sea (Thompson and A Scott), the east side of the North Atlantic Ocean (Sars) and the Mediterranean Sea (Pesta, Rose). Rose (1929. p. 39) gives the northern limit of its distribution in the Atlantic as the Gulf of Gascony.

Candacia pachydactyla (Dana).

Candacia pachydactyla, Giesbrecht, 1892, p. 424, pl. xxi, fig. 17, pl. xxii, figs. 11, 19, pl. xxxix, figs. 30–33; Wilson, 1932, p. 141, fig. 96, *a*, *b*.

Occurrence:

- Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 1 female.
- Sta. 61 C, Northern area of Arabian Sea, surface, 1 female.
- Sta. 131 D, Southern area of Arabian Sea 500–0 m., 2 females, 1 male; 1500–0 m., 2 females, 1 male.
- Sta. 135, Maldive area, surface, 1 male.
- Sta. 145 C, Maldive area, 50–0 m. vertical, 3 females; 300–0 m. vertical, 2 females, 1 male.
- Sta. 145 D, Maldive area, 100–0 m., vertical, 1 male; 500–0 m. vertical, 1 female.
- Sta. 172, Central area of Arabian Sea. 200–0 m., 1 male: 400–0 m., 2 females, 1 male; 850–0 m., 1 male.

Distribution.—The east Pacific Ocean (Giesbrecht), the south China Sea, off New Holland, the Philippine Islands and Fiji (Brady), the Malay Archipelago (A. Scott), the Aru Archipelago (Früchtl), the coast of South Burma (Sewell), Nankauri Harbour, Nicobar Islands (Sewell), Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden, present records), the Arabian Sea (Thompson and A. Scott), east of Cape Colony (Cleve), west of Cape Colony (Cleve), Gulf of Guinea (T. Scott), the south Atlantic Ocean (Brady, Giesbrecht, Wolfenden, T. Scott), the equatorial and north Atlantic Ocean (Lubbock, Giesbrecht, Wolfenden, Farran, Sars, Rose), the Woods Hole region of the American coast (Wilson) and the Mediterranean Sea (Thompson).

Candacia simplex (Giesbrecht).

Candacia simplex, Giesbrecht, 1892, p. 424, pl. xxi, figs. 10, 30, 31, pl. xxii, figs. 21, 29, pl. xxxix, figs. 3, 14.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m., 1 female.

Distribution.—The Pacific Ocean (Giesbrecht), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott, Sewell), the Indian Ocean (Cleve), the Arabian Sea (Thompson and A. Scott, present record), the

Red Sea (Thompson and A. Scott), the tropical Atlantic Ocean (Wolfenden, Farran), the North Atlantic Ocean (Wolfenden, T. Scott) and the Mediterranean Sea (Thompson and A. Scott, Pesta, Rose).

Candacia varicans Giesbrecht.

Candacia varicans, Giesbrecht, 1892, p. 424, pl. xxi, figs. 3, 4, 11, pl. xxii, figs. 10, 25, pl. xxxix, figs. 2, 23.

Occurence :

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 1 female.

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female.

Distribution.—Off New Zealand (Farran), the Laccadive Sea (Sewell), the Arabian Sea (present records), the east coast of South Africa (Cleve), the South Atlantic Ocean (Wolfenden), the Gulf of Guinea (T. Scott), the tropical Atlantic (Wolfenden), the temperate North Atlantic Ocean (Farran) and the Mediterranean Sea (Giesbrecht).

Family Pontellidæ.

Genus *Calanopia* Dana.

Calanopia, Giesbrecht, 1892. p. 441 ; Giesbrecht and Schmeil, 1898, p. 131.

Calanopia elliptica (Dana).

Calanopia elliptica, Giesbrecht, 1892, p. 441, pl. xxxi, figs. 23–26, 31, 32, pl. xxxviii, figs. 42, 47 ; *idem*, 1896, p. 325, pl. v, figs. 7–9 ; A. Scott, 1909, p. 176, pl. xlviii, figs. 1–5.

Occurrence.—Sta. 56, South Arabian Coast, surface, 2 males.

Distribution.—In the Western Pacific from Hong Kong (Giesbrecht), the Philippine Islands (Brady), the Great Barrier Reefs of Australia (Farran), the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean from the coast of Southern Burma, Nankauri Harbour, Nicobar Islands, and the Bay of Bengal (Sewell), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Cleve, A. Scott), the Persian Gulf (Pesta), the south coast of Arabia (present record), the Red Sea (Thompson, Giesbrecht, A. Scott), the Suez Canal (Gurney), the east coast of Africa (Thompson) and in the Mediterranean Sea (Thompson).

Genus *Labidocera* Lubbock.

Labidocera, Giesbrecht, 1892, p. 444 ; Giesbrecht and Schmeil, 1898, p. 132.

Labidocera acuta (Dana).

Pontella acuta, Brady, 1883, p. 89, pl. xxxvi, figs. 1–12.

Labidocera acutum, Giesbrecht, 1892, p. 445, pl. xxiii, figs. 15, 44, 46, pl. xxv, figs. 31, 33, pl. xli, figs. 10, 19, 20, 28, 29, 40.

Occurrence :

Sta. 45, South Arabian Coast, 38 m., 1 male.

Sta. 56, South Arabian Coast, surface, 3 females, 57 males.

Sta. 58, South Arabian Coast, surface, 11 specimens.

Sta. 76, Gulf of Oman, 200–0 m., 6 females, 2 males ; 600–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 850–0 m., 2 females, 2 males.

Distribution.—The Californian coast of America (Giesbrecht), the western region of the Pacific Ocean (Giesbrecht), the south-west Pacific Ocean (Dana, Brady), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott), the Aru Archipelago (Früchtl), the coast of southern Burma and Nankauri Harbour, Nicobar Islands (Sewell), the Bay of Bengal (Thompson), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Indian Ocean (Giesbrecht), the Arabian Sea (Pesta, present records), the Persian Gulf (Pesta), the Red Sea (Giesbrecht, A. Scott), the east coast of Africa (Wolfenden, Brady, Thompson), the Agulhas current (Cleve), the Gulf of Guinea (T. Scott), the Altantic, Ocean (van Breemen) and Port Erin, Isle of Man (Thompson).

Labidocera acutifrons (Dana).

Labidocera auctifrons, Giesbrecht, 1892, p. 445, pl. xxiii, figs. 2, 12, 30, 33, 40, 41, pl. xli, figs. 3, 26, 4L ; Wilson, 1932, p. 145, fig. 98, *a–d*.

Occurrence :

Sta. 56, South Arabian Coast, surface, 2 females, 1 male.

Sta. 58, South Arabian Coast, surface, 1 male.

Distribution.—Off the west coast of South America and in the eastern Pacific region between 110°–147° W., 25°–30° N. (Giesbrecht), in the western Pacific area off New Holland, the Philippine Islands, Sandwich Islands and Ki Islands (Brady), the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl), the Arabian Coast (present records), the west region of the Indian Ocean (Thompson), the Antarctic Ocean (Wolfenden), the Gulf of Guinea (T. Scott), the tropical Atlantic (Farran, Giesbrecht), the North Atlantic (T. Scott), in the Woods Hole region (Wilson), off Cape Verde Islands (Brady) and in the western part of the Mediterranean Sea (Giesbrecht.)

Labidocera detruncata (Dana).

Pontella detruncata, Brady, 1883, p. 90, pl. xxvi, figs. 8–15, pl. xlv, fig. 20.
Labidocera detrcunatum, Giesbrecht, 1892, p. 445, pl. xxiii, figs. 14, 34, pl. xxv, fig. 28, pl. xli, figs. 9, 30, 31 ; Wolfenden, 1906, p. 1017, pl. xcviii, figs. 18, 21, 34, 36.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 2000–0 m., 2 females, 1 male.

Sta. 61 C, Northern area of Arabian Sea, surface, 3291 specimens ; 1000–0 m., 11 females, 11 males ; 1500–0 m., 2 males.

Distribution.—Pacific Ocean, 110° W., 10° S. (Streets), south of the Hawaian Islands (Brady), 175° E. to 178° W., 0°–26° S. (Dana), South China Sea (Giesbrecht), Australian Barrier Reefs (Farran), Malay Archipelago (A. Scott), Nankauri Harbour, Nicobar Islands, and Bay of Bengal (Sewell), the Indian Ocean 45°–75° E. (Giesbrecht), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present records) and Durban Bay (Brady). A variety of this species, var. *intermedia*, was recorded by T. Scott from the Gulf of Guinea.

Labidocera minuta Giesbrecht.

Labidocera minuta, Giesbrecht, 1892, p. 446, pl. xxiii, figs. 16, 35, 36, pl. xxv, fig. 32, pl. xli, figs. 8, 15, 16, 35.

Occurrence.—Sta. 56, South Arabian Coast, surface, 12 males, 1 female.

Distribution.—Hong Kong (Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott, Früchtl), the coast of southern Burma and the Mergui Archipelago (Sewell), Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (A. Scott, Cleve, present record), the Persian Gulf (Pesta), the Red Sea (Giesbrecht, A. Scott) and the Suez Canal (Gurney).

Genus *Pontella* Dana.

Pontella, Giesbrecht, 1892, p. 461 ; Giesbrecht and Schmeil, 1898, p. 139.

Pontella fera Dana.

Pontella fera, Giesbrecht, 1892, p. 462, pl. xxiv, figs. 14, 31, 34, 36, pl. xl, figs. 15, 18, 27, 36.

Occurrence.—Sta. 172, Central area of Arabian Sea, 400–0 m., 1 male.

Distribution.—The western region of the Pacific Ocean (Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Laccadive Sea (Giesbrecht), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present record), the Red Sea (A. Scott), the South Atlantic Ocean, west of Cape Colony (Wolfenden).

Pontella securifer Brady.

Pontella securifer, Brady, 1883, p. 96, pl. xlv, figs. 1–9 ; Giesbrecht, 1892, p. 461, pl. xxiv, figs. 9, 37, 41, 43, pl. xl, figs. 6, 14, 21, 32, 34 ; Wilson, 1932, p. 151, fig. 102, *a–c*.
Pontella spinipes, ♂, Wolfenden, 1906, p. 1020.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 3 females ; 1500–0 m., 1 female, 1 juv.

Sta. 61 C, Northern area of Arabian Sea, surface, 59 females, 21 males.

Sta. 76, Gulf of Oman, 1500–0 m., 1 female.

Sta. 172, Central area of Arabian Sea, 200–0 m., 1 female ; 850–0 m., 1 female.

Sta. 186, Gulf of Aden, 250–0 m., 1 female.

Remarks.—The present specimens of the male agree closely with the description given by Wolfenden (1906) of the male that he attributed to *P. spinipes*.

Distribution.—In Puget Sound on the West Coast of North America (Thompson), the tropical area of the Pacific Ocean (Brady, Giesbrecht), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott), the coast of Southern Burma (Sewell), Nankauri Harbour, Nicobar Islands (Sewell), the Madras Coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden, Thompson and A. Scott), the Arabian Sea and Gulf of Oman (present records), east of South Africa (Cleve), Simon's Bay, Cape Colony (Wolfenden), the South Atlantic Ocean (T. Scott), the Gulf of Guinea (T. Scott), the Woods Hole region of North America (Wilson), and the Mediterranean Sea (Thompson).

Genus *Pontellopsis* Brady.

Monops, Giesbrecht, 1892, p. 486.
Pontellopsis, Giesbrecht and Schmeil, 1898, p. 145.

Pontellopsis armata (Giesbrecht).

Monops armata, Giesbrecht, 1892, p. 487, pl. xxvi, figs. 19, 26, 27, pl. xli, figs. 46, 47, 58.

Occurrence.—Sta. 172, Central part of Arabian Sea, 850–0 m., 1 female.

Distribution.—The western Pacific Ocean in lat. 10° N., long. 137° E. (Giesbrecht), the Malay Archipelago (Cleve, A. Scott), Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Laccadive Sea (Giesbrecht), the Maldive Archipelago (Wolfenden) and the Arabian Sea (present record).

Pontellopsis perspicax (Dana).

Monops perspicax, Giesbrecht, 1892, p. 486, pl. xxvi, figs. 15, 30, pl. xli, figs. 44, 49, 55, 59.
Pontellopsis perspicax, Giesbrecht and Schmeil, 1898, p. 147.

Occurrence.—Sta. 172, Central area of Arabian Sea, 200–0 m., 1 female.

Distribution.—The Malay Archipelago (A. Scott), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Arabian Sea (present record), in the tropical Atlantic south of the equator (Farran), the equatorial Atlantic (Dana, Giesbrecht) and in the North Atlantic to lat. 13° N. (T. Scott).

Pontellopsis regalis (Dana).

Monops regalis, Giesbrecht, 1892, p. 486, pl. i, fig. 6, pl. xxvi, figs. 3, 6–9, 13, 14, 20, 21, pl. xli, figs. 50, 54, 56, 62, 64, 66, 67.
Pontellopsis regalis, Giesbrecht and Schmeil, 1898, p. 147.

Occurrence :

Sta. 61 C, Northern part of Arabian Sea, 1500–0 m., 1 male.
Sta. 145 D, Maldive Area, 500–0 m., vertical, 1 female.
Sta. 172, Central area of Arabian Sea, 850–0 m., 1 female.

Distribution.—The west coast of South America (Giesbrecht), Hong Kong (Giesbrecht), Sulu Sea (Dana), the south-west Pacific Ocean between Sydney, Australia and Wellington, New Zealand (Brady), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott), the coast of Southern Burma, Nankauri Harbour, Nicobar Islands (Sewell), the Bay of Bengal (Thompson), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive area and the Arabian Sea (present records), the tropical Atlantic Ocean (T. Scott, Farran, Lubbock, Wolfenden), the Woods Hole region (Wilson) and the Mediterranean Sea and Adriatic (Pesta).

Genus *Pontellina* Dana.

Pontellina plumata (Dana).

Pontellina plumata, Giesbrecht, 1892, p. 497, pl. iv, fig. 11, pl. xxv, figs. 4, 18, 26, 36, pl. xl, figs. 49–53 ; Giesbrecht and Schmeil, 1898, p. 149.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface.

Distribution.—The west coast of America between lats. 9° S. and 15° N. (Giesbrecht), Fiji and the Philippine Islands (Brady), off New Zealand (Farran), the Great Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott, Lubbock), the Aru Archipelago (Früchtl), the coast of Southern Burma (Sewell), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present record), the Red Sea (A. Scott), the east coast of Africa and the Agulhas Current (Cleve), off the Cape of Good Hope (Dana), the South Atlantic Ocean (Farran), the Brazil current (Cleve), the Gulf of Guinea (T. Scott), the tropical Atlantic Ocean (T. Scott, Farran), the Woods Hole region (Wilson), the north temperate Atlantic (Farran, Sars, Rose), and the Mediterranean Sea (Sars, Rose, Thompson)

Family Acartiidæ.

Genus *Acartia* Dana.

Acartia, Steuer, 1923.

Sub-genus *Acanthacartia* Steuer.

Acartia (*Acanthacartia*) *pietschmani* Pesta.

Acartia pietschmani, Pesta, 1912, p. 54, fig. 18, *a–d*.
Acartia (*A anthacartia*) *pietschmani*, Steuer, 1923, p. 109.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, 1 female.

Distribution.—The Great Barrier Reefs (Farran), the Ceylon Pearl Banks (Sewell), the Arabian Sea (Pesta, present record), and the Persian Gulf (Pesta).

Sub-genus *Odontacartia* Steuer.

Acartia (*Odontacartia*) *amboinensis* Carl.

Acartia amboinensis, ♂, Carl, 1907, p. 12, pl. i, figs. 3–5 ; ♀, Sewell, 1914, p. 242, pl. xix, figs. 1–7.
Acartia (*Odontacartia*) *amboinensis*, Steuer, 1923, p. 120, figs. 151–156.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, several specimens of both sexes.

Distribution.—The Malay Archipelago (Carl), the coast of Southern Burma (Sewell), the Ceylon Pearl Bank (Sewell), the northern area of the Arabian Sea (present record) and the entrance to the Gulf of Aden (Steuer).

Acartia (*Odontacartia*) *erythræa* Giesbrecht.

Acartia erythræa, Giesbrecht, 1892, p. 508, pl. xxx, figs. 5, 19, 32, pl. xliii, figs. 12, 13.
Acartia (*Odontacartia*) *erythræa*, Steuer, 1923, p. 118, figs. 142–145.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface.

Distribution.—The Malay Archipelago (Cleve, A. Scott, Carl), the Aru Archipelago (Früchtl), off Penang (Sewell), the coast of southern Burma, Nankauri Harbour, Nicobar Islands (Sewell), the coast of Madras (Menon), the Ceylon Pearl Banks (Thompson and A. Scott, Sewell), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Pesta, Cleve, present record), the Persian Gulf (Pesta), the Red Sea (Giesbrecht, A. Scott) and Durban Bay, East Africa (Brady).

CYCLOPOIDA.

Section GNATHOSTOMA.

Family Oithonidæ.

Sub-family Oithoninæ.

Genus *Oithona* Baird.

Oithona attenuata Farran.

Oithona attenuata, Farran, 1913, p. 187, pl. xxx, figs. 3–7 ; Rosendorn, 1917, p. 42, text-fig. 25, *a–h* ; Kiefer, 1929, p. 8.
Oithona attenuata, var. *latithoracica*, Früchtl, 1924, p. 71, figs. 47, 48.
Oithona attenuata, var. *latithoracica* f. *trisetosa*, Früchtl, 1924, p. 73.

Occurrence.—" Investigator " collections, Expedition Harbour, Camorta Island, Nicobars, several specimens.

Remarks.—So far as I was able to make out, these examples agreed with the description given by Farran.

Distribution.—The Pacific Ocean, Pago Pago Harbour, Samoa (Rosendorn), the Australian Barrier Reefs (Farran), the Indian Ocean, off Christmas Island (Farran), in the Nicobar Islands (present record), near the Maldive Archipelago and in the south-west part of the Arabian Sea (Rosendorn) and near the Cape of Good Hope (Rosendorn). It also occurs sporadically in the Atlantic Ocean according to Rosendorn.

Oithona brevicornis Giesbrecht.

Oithona brevicornis, Giesbrecht, 1892, p. 546, pl. xxxiv, figs. 6, 7 ; Rosendorn, 1917, p. 34, text-fig. 19, *a–g*, 20, *a–f* ; Kiefer, 1929, p. 8.
Oithona brevicornis, f. *aruensis*, Früchtl, 1924, p. 66, fig. 44.
Oithona brevicornis, f. *arostrata*, Früchtl, 1924, p. 69, figs. 45, 46.

Occurrence.—Sta. 56, Coast of Southern Arabia, surface.

Remarks.—This species, like *Oithona nana*, possesses a great degree of tolerance to brackish water.

Distribution.—In the Pacific Ocean off Hong Kong (Giesbrecht), in the Malay Archipelago (Cleve), the Aru Archipelago (Früchtl), Verlaten Island, Sunda Straits (Sewell), Kurau River, Malay States, mouth of the Hoogli River, Calcutta Salt Lakes, Chilka Lake (Sewell), the tropical Atlantic Ocean (Cleve), east coast of North America, Chesapeake Bay (Wilson), Penzance Ponds, Woods Hole (Wilson) and in the Adriatic Sea (Pesta).

Oithona fallax Farran.

Oithona fallax, Farran, 1913, p. 185, pl. xxvii, figs. 9–12, pl. xxviii, figs. 1–3 ; Rosendorn, 1917, p. 27, text-figs. 14, *a*, *b*, 15, *a–h* ; Kiefer, 1929, p. 7.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, 2 females.

Descriptive Notes.—♀. Total length 0·87 mm. The proportional lengths of the anterior and posterior regions of the body are as 49 to 38 ; Farran gives 48 to 42 and

Rosendorn 47 to 42. The proportional lengths of the segments of the posterior region are as follows :

Segment.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	15	31	15	15	14	10 = 100

The outer furcal seta is twice the length of the furcal ramus.

The present examples both differ from the description given by Farran in that the terminal segment of the endopod of the 1st leg bears 6 inner setæ and 1 outer seta—7 in all ; whereas Farran states that in his specimens there were five inner edge setæ and 1 outer ; he, however, shows 7 setæ in all in his figure. A small very delicate seta is present on the inner margin of the 1st segment of the exopod of the 1st leg in these examples.

Distribution.—Off Christmas Island (Farran), the Indian Ocean, Arabian Sea and the Agulhas Current (Rosendorn), the northern area of the Arabian Sea (present record) and in the south temperate and tropical parts of the Atlantic Ocean (Rosendorn).

Oithona nana Giesbrecht.

Oithona nana, Giesbrecht, 1892, p. 538, pl. iv, fig. 8, pl. xxxiv, figs. 10, 11, 20, 24–26, 34, 35 ; Rosendorn, 1917, p. 40, text-fig. 24, *a–d* ; Gurney, 1927, p. 159 ; Pesta, 1928, p. 76, fig. 58 ; Kiefer, 1929, p. 9.

Occurrence.—Sta. 56, South coast of Arabia, surface.

Remarks.—Sars (1913–18, p. 207) has suggested that *Oithona helgolandica* Claus and *O. nana* Giesbrecht are synonyms ; Rosendorn (1917) apparently inclines to this view, and Pesta (1928) has adopted it. If this be the case, then Claus' name *helgolandica* has priority.

Gurney (1927) has suggested that there are two forms of this species, a northern, smaller form, measuring 0·53–0·55 mm., and a southern, larger form, measuring 0·62–0·69 mm. The present forms measured 0·56 mm.

Distribution.—East Pacific, San Diego Region (Esterly), the south-west Pacific Ocean, Samoa (Rosendorn), the Malay Archipelago (Cleve), the Aru Archipelago (Früchtl). Kurau River, Malay States (Sewell), Indian Ocean, Christmas Island (Farran), Ceylon Pearl Banks (Thompson and A. Scott), Nankauri Harbour, Nicobar Islands (Sewell), the Maldive Archipelago (Wolfenden), the Chilka Lake (Sewell), the Arabian Sea (Cleve), the south coast of Arabia (present record), the Red Sea (Giesbrecht), the Gulf of Suez (Gurney), the mouth of the Congo River (Rosendorn), the east coast of North America, Narragansett Bay (Williams), Woods Hole region (Wilson), the North Atlantic Ocean (Cleve), south-west of Ireland (Thompson), the English Channel, the coasts of Holland, north of Jutland and off the west coast of Sweden (Cleve) and the Mediterranean Sea (Giesbrecht, Steuer, Pesta, Rose).

As I have previously (Sewell, 1933) pointed out, this species is tolerant of brackish water conditions.

Oithona oculata Farran.

Oithona oculata, Farran, 1913, p. 188, pl. xxx, figs. 8, 9, pl. xxxi, figs. 2–9 ; Rosendorn, 1917, p. 37, text-fig. 23, *a–g* ; Kiefer, 1929, p. 10.

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface, 1 male.

Descriptive Notes.—♂. In its general form this example agrees closely with the

description given by Rosendorn. The proportional length of the segments of the abdomen are as follows :

Abd. 1.	Abd. 2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
23	18	17	16	14	12 = 100

The furcal rami are twice as long as broad.

The 1st antenna closely resembles that of the male of *Oithona rigida* Giesbrecht. It is extremely difficult to make out the total number of segments, but there appear to be 13 in all, of which the 2nd and 3rd and the 4th to 6th respectively form overlapping groups. The 9th and 10th segments each bear a serrated spine on the anterior margin ; segment 10 also bears a single sensory filament. The knee-joint lies between segments 11 and 12. Segment 12 bears a sensory filament about the middle of its length, and segment 13 bears two unequal sensory filaments, one slender and the other very stout at its distal end.

In the maxilliped the 2nd and 3rd segments each bear a single stout S-shaped spine, that is fringed with fine needle-like spinules.

In the swimming legs the terminal spines of the exopods are very long, exceeding in length the whole ramus.

The 5th leg bears two setæ distally.

Distribution.—In the Pacific Ocean, Samoa (Rosendorn) and in the Indian Ocean, Christmas Island (Farran) and Nankauri Harbour, Nicobar Islands (present record).

Oithona plumifera Baird.

Oithona plumifera, Giesbrecht, 1892, p. 537, pl. iv, fig. 10, pl. xxxiv, figs. 12, 13, 22, 25, 27–29, 32, 33, pl. xliv, figs. 1, 7, 12–15 ; Rosendorn, 1917, p. 10, text-fig. 1, *a–d* ; Kiefer, 1929, p. 4.

Occurrence :

Sta. 61, surface, Northern area of Arabian Sea, numerous examples.

Sta. 96, Central area of Arabian Sea, 10 m., 7 females, 1 male.

Remarks.—♀. Total length 1·12–1·20 mm. The proportional lengths of the thoracic and abdominal regions of the body are as 57 to 43. The proportional lengths of the segments of the posterior region are as follows :

Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
12	31	16	17	14	10 = 100

The segments of the 1st antenna are fringed with small spinules, as figured by Giesbrecht (1892, pl. xxxiv, fig. 33).

In some of the specimens the plumose setæ arising from the swimming legs are present, but in others they were either present only on the anterior two pairs of legs or were apparently absent altogether. Farran (1913, p. 183) has already pointed out that in some examples these setæ are not present, or at least were not visible, on the posterior limbs, and he suggests that they may have been broken off, but in several examples that I examined most carefully the posterior setæ tapered to a very delicate point, and showed no sign of being broken and equally no sign of any feathering. It seems probable that the plumose termination is a variable character and may in some cases be wanting.

Remarks.—Rosendorn (1917) considers that *Oithona spinirostris* Claus is synonymous with *O. plumifera* Baird ; as, however, Claus clearly shows four setæ arising from the

endopod of the mandibular palp, which is a character of *O. atlantica* Farran, whereas *O. plumifera* only possesses three such setæ, I prefer to follow Sars, who regards Claus' *spinirostris* and Farran's *atlantica* as synonyms, the former name having priority. Kiefer (1929, p. 4) regards the form described by Sars (1913) in his 'Crustacea of Norway' as *O. spinirostris* as synonymous with *O. plumifera*.

Distribution.—This species has a very wide distribution, though, owing to the confusion that has arisen regarding the identity of this and other very closely related species, the exact limits cannot be determined. It appears probable that it occurs throughout the whole of the tropical and temperate regions of the three great oceans, and in the south has been able to get into and survive in the West Wind Drift; in the north it probably does not extend beyond the British Isles.

Oithona rigida Giesbrecht.

Oithona rigida, Giesbrecht, 1897, p. 324, pl. v, figs. 10–15; Cleve, 1901, p. 45, pl. v, figs. 7–18; Wolfenden, 1906, p. 1023, pl. xcix, fig. 42; Rosendorn, 1917, p. 39; Kiefer, 1929, p. 10.

Occurrence.—Sta. 61, Northern area of Arabian Sea, surface, 1 female.

Descriptive Notes.—Total length 0·83 mm. The proportional lengths of the anterior and posterior regions of the body are as 55 to 45. The cephalothorax is broadly oval, being widest about the posterior margin of the cephalon. The anterior margin is truncate when viewed from above, but seen from the side is produced downwards and forwards in a short, bluntly-rounded prominence. The proportional lengths of the segments of the posterior region are as follows:

Segment	Th. 4.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	12	29	16	16	13	14 = 100

The furcal rami are 2·33 times as long as broad. The outer seta is delicate and is shorter than the ramus; it arises slightly on the proximal side of the middle of the ramus; the 2nd furcal seta is the longest, and is equal in length to abdominal segments 3–5 plus the furcal ramus.

The 1st antenna reaches back to the posterior margin of the 2nd thoracic segment; it consists of 14 segments, having the following proportional lengths:

Segment 1.	2.	3–4.	5.	6.	7.	8.	9.	10.	11.	12.	13–14
9	7	12	6	12	10	13	5	12	3	6	5 = 100
		(8–4)									(3–2)

Segments 3 and 4 and 13 and 14 respectively are almost completely fused, and 5 and 6 are partially fused. There is a short spinous prominence on the distal margin of the 5th segment (the 4th segment if segments 3 and 4 are counted as one).

The mouth parts are as figured by Cleve (1901).

In the swimming legs the terminal spine of the 3rd segment of the exopod is very considerably shorter than the ramus itself and, except in the 1st leg, it is shorter than the 3rd segment of the exopod, as is shown below—

	Total length of exopod.		Length of exopod 3.		Length of spine.
P. 1	25	.	11	.	14
P. 2	36	.	20	.	16
P. 3	39	.	22	.	19
P. 4	32	.	20	.	19

In the 1st foot the exopod bears 1, 1, 3 outer spines and 1, 1, 4 inner setæ ; the endopod bears 1, 1, 5 inner setæ and 0, 0, 1 outer setæ. Farran (1913, p. 189) states that there are only 1, 1, 4 inner setæ on the endopod in *Oithona oculata*. Rosendorn (1917, p. 39) gives the number of inner setæ on the 3rd segment of the exopod as 1, 1, 5 ; this is incorrect.

In the 2nd and 3rd legs the exopod bears 1, 1, 3 outer spines and 1, 1, 5 inner setæ ; the endopod bears 1, 2, 5 inner setæ and 0, 0, 1 outer setæ.

The 4th leg bears on the exopod 1, 1, 2 outer spines and 1, 1, 5 inner setæ ; and the endopod bears 1, 2, 4 inner setæ and 0, 0, 1 outer setæ.

Distribution.—This species appears to be widely distributed throughout the northern region of the Indian Ocean. It has been recorded from the Malay Archipelago (Cleve, A. Scott), Nankauri Harbour, Nicobar Islands (Sewell), the Ceylon Pearl Banks and Laccadive Sea (Thompson and A. Scott), the Maldive Archipelago (Wolfenden), the Arabian Sea (Thompson and A. Scott), the northern area of the Arabian Sea (present record), the Gulf of Aden (Cleve) and the Red Sea (Giesbrecht).

Oithona setigera (Dana).

Oithona setigera, Giesbrecht, 1892, p. 546, pl. xxxiv, figs. 3, 14, 15, 41 ; Rosendorn, 1917, p. 20, text-fig. 10, *a–c* ; Kiefer, 1929, p. 6.
Oithona pelagica, Farran, 1908, p. 501.
Oithona tropica, Wolfenden, 1906, p. 1023, pl. xcix, figs. 44–48.

Occurrence.—" Investigator," Sta. 614, Nankauri Harbour, surface, several examples.

Remarks.—Wolfenden (*loc. cit.*) claims that his *Oithona tropica* differs from *O. setigera* in the absence of the club-shaped bristles on the 2nd basals of the 2nd pair of swimming legs, and in the different proportions of the thorax and abdomen and the relative lengths of the segments of the latter. The presence of a club-shaped seta on the 2nd leg does not appear to be a reliable character : Rosendorn has stated that in some instances the outer setæ of the other swimming legs are also club-shaped, and in the form described by Farran under the name *O. pelagica* this club-shaped seta was not present even on the 2nd leg.

Distribution.—In the western part of the Pacific Ocean (Dana, Giesbrecht), east Pacific region (Giesbrecht), the Sandwich Islands, New Holland, New Guinea (?) (Brady), New Zealand (Farran), the Australian Barrier Reefs (Farran), Nankauri Harbour, Nicobar Islands (Sewell), the Maldive Archipelago (Wolfenden), the Red Sea and the Gulf of Suez (Rosendorn), the Gulf of Guinea (T. Scott), the coast of Ireland (Farran), the Mediterranean Sea (Thompson and A. Scott, Steuer, Pesta) and the Bay of Biscay (Farran).

Genus *Lubbockia* Claus.

Lubbockia aculeata Giesbrecht.

Lubbockia aculeata, Giesbrecht, 1892, p. 606, pl. xlviii, figs. 3, 9, 11, 13, 16, 20.

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface, 1 female.

Descriptive Notes.—♀. Total length 2·22 mm. The proportional lengths of the anterior and posterior regions of the body are as 53 to 47. The proportional lengths of the segments of the posterior region are as follows :

Segment	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	13	26	16	16	16	13 = 100.

The anterior third of the genital segment is swollen and globular, and behind this the transverse diameter is sharply constricted.

Distribution.—In the tropical region of the Pacific Ocean, eastern area (Giesbrecht), off the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott) ; in the Indian Ocean in Nankauri Harbour, Nicobar Islands (present record) and the Red Sea (Cleve).

Section PŒCILOSTOMA.

Family Oncæidæ.

Genus *Oncæa* Philippi.

Oncæa clevei Früchtl.

Oncæa clevei, Früchtl, 1923, p. 455, pl. xxvi, figs. 19–22 ; *idem*, 1924, p. 89, figs. 62–70.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, several examples.

Descriptive Notes.—♀. Total length 0·68 mm. The proportional lengths of the anterior and posterior regions of the body are as 63 to 37. The proportional lengths of the segments of the posterior region are as follows :

Segment	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	9	48	10	8	10	15 = 100

The posterior segments of the abdomen are provided with a stout chitinous covering. The furcal rami are two and a half times as long as broad. The dorsal projection on the 2nd thoracic segment varies considerably in its development.

Remarks.—A few specimens are infected with a parasitic Peridinian, that appears to be *Blastodinium mangini* Chatton (1920).

Distribution.—This species has now been recorded from the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve), the Aru Archipelago (Früchtl) and the Arabian Sea (present record).

Oncæa conifera Giesbrecht.

Oncæa conifera, Giesbrecht, 1892, p. 591, pl. ii, fig. 10, pl. xlvii, figs. 4, 16, 21, 28, 34, 42, 55, 56 ; Esterly, 1906, p. 216, fig. 55, *a*, *b* ; Farran, 1936, p. 127, text-figs. 25, *a–f*, 26, *a–c*.

Occurrence :

Sta. 56, South coast of Arabia, surface, 1 female.

Sta. 61, Northern area of Arabian Sea, surface, 1 female.

" Investigator," Sta. 614, Nankauri Harbour, Nicobar Islands, surface, 1 female.

Descriptive Notes.—♀. Total length 1·18 mm. The proportional lengths of the anterior and posterior regions of the body are as 64 to 36. The proportional lengths of the posterior region of the body are as follows :

Segment	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	16	42	8	6	14	14 = 100

The length and breadth of the furcal rami are as 2·5 to 1. These specimens agree with type (*a*) of Farran (1936).

In the present specimens and another that I examined from the Nicobar Islands the distal seta on the 2nd segment of the basipodite of the maxilliped is longer and stouter than the proximal one, and the end-claw is fringed with somewhat stout teeth instead of needle-like spinules ; in the 4th swimming leg the proximal spine on the outer margin of the 3rd segment of the endopod is simple and not serrate, and is more delicate than the distal spine ; and in the 5th leg the longer of the two setæ is stouter than the shorter one. In all these characters these examples agree with the descriptions of specimens from the Atlantic Ocean, and differ from Giesbrecht's account of the specimens from the Antarctic Ocean.

Remarks.—Included under the term "*conifera*" we have either a species that is extremely plastic, or more probably a number of separate races. The name was originally applied by Giesbrecht (1892) to a form taken in the western Pacific Ocean and off Naples in the Mediterranean Sea ; in a subsequent paper he (1902) included under the same name a form that was taken by the " Belgica " in the Antarctic, and in this paper he notes that three " varieties " of the species can be recognized, namely, a warm-water Pacific-Mediterranean form, an Arctic form and an Antarctic form. The Arctic form was later separated off as a distinct species by Sars (1913–18, p. 191) with the name *O. borealis*. Sars also pointed out that the form which Cleve had recorded from the Malay Archipelago under the name *conifera* was in reality a very different species ; this Malayan form was fully described by Früchtl (1923, p. 455, pl. xxvi, figs. 19–22 ; and 1924, p. 89, figs. 62–70), and was named *O. clevei*. Farran (1929, p. 285) has recorded the occurrence of both the typical Pacific-Mediterranean form and the Antarctic form in the " Terra Nova " collections, the Antarctic form occurring only to the south of lat. 60° S. In 1936, however, he records no less than three different forms of this species from the Australian Barrier Reef.

In the following table I have given the main characteristic features of the various forms, but there are further slight differences between the Antarctic form and the Pacific-Mediterranean form. In the former the distal claw-like segment of the maxilliped is armed, according to Giesbrecht's figure (1902, pl. xiii, fig. 9), with delicate needle-like spinules, whereas in the Pacific-Mediterranean form it is armed with coarser teeth ; again

in the third segment of the endopod of the 4th swimming leg of the Pacific-Mediterranean form the proximal spine on the outer margin is considerably more delicate than the distal spine, whereas in the Antarctic form Giesbrecht (1902, pl. xiii, fig. 10) figures the two spines as approximately of the same thickness; finally, in the same segment the distal external marginal spine arises in the Pacific-Mediterranean form much nearer the distal end of the segment than in the Antarctic form (*cf.* Giesbrecht, 1892, pl. xlvii, fig. 38, and Farran, 1936, fig. 26, with Giesbrecht, 1902, pl. xiii, fig. 10).

	Mediterranean form.	Australian Barrier Reef.			Antarctic form.
		Form A.	Form B. f. *furcula*.	Form C.	
Total length, ♀ .	1·15–1·23 mm.	1·15–1·20 mm.	1·08–1·14 mm.	0·96–1·02 mm.	1·10–1·25 mm.
Greatest width of cephalothorax	..	$3\frac{1}{4}$ times in total length	$3\frac{2}{3}$ times in total length	$3\frac{1}{2}$ times in total length	..
Dorsal projection of Th. 2	Well marked	Well marked	Slight	Slight	Well marked
Lateral extensions of Th. 4.	..	Parallel sided	Inclining outwards	Parallel sided	..
Length of abdomen and Th. 5	$1\frac{4}{5}$ times in the anterior region	$1\frac{3}{4}$ times in the anterior region	$1\frac{2}{3}$ times in the anterior region	$1\frac{2}{3}$ times in the anterior region	$1\frac{4}{5}$ times in the anterior region
Genital segment	Swollen anteriorly and tapered posteriorly	Slightly swollen anteriorly and tapered posteriorly to $\frac{1}{2}$ the anterior width	Slender	Stout and very slightly tapered	Slightly swollen anteriorly and very slightly tapered
	Longer than the rest of the abdomen by the length of the furcal ramus	Ditto	Longer than the rest of the abdomen by the length of the furca and anal segment	Longer than the rest of the abdomen by the length of the furca and $\frac{2}{3}$ the anal segment	As long as the rest of the abdomen
Anal segment .	Equal to preceding 2 segments	Ditto	Only slightly longer than either of the preceding 2 segments	Equal to $\frac{3}{4}$ of the preceding 2 segments	..
Furcal rami . .	Equal to anal segment	Ditto	Ditto	Ditto	$1\frac{1}{3}$ as long as the anal segment
	Parallel sided	Parallel sided	Oval, rather than parallel sided	Parallel sided	Parallel sided
	2–$2\frac{1}{2}$ times as long as broad	Twice as long as broad	..	..	4 times as long as broad
4th swimming leg :					
(*a*) Conical process at distal end	Rounded ; reaches to $\frac{2}{5}$ along the end-spine	Broadly rounded ; reaches to $\frac{1}{2}$ way along the end-spine	Narrowly rounded ; reaches to $\frac{1}{2}$ way along the end-spine	Pcinted ; reaches to $\frac{1}{2}$ way along the end-spine	Rounded ; reaches to $\frac{1}{6}$ way along the end-spine
(*b*) Terminal spine	$4\frac{3}{4}$ times in the length of exopod 3	$3\frac{5}{6}$ times in the length of exopod 3	7 times in the length of exopod 3	$4\frac{1}{2}$ times in the length of exopod 3	$3\frac{1}{2}$ times in the length of exopod 3
5th foot . .	3 times as long as broad	..	..	..	Scarcely longer than broad

Distribution.—Owing to the confusion that has existed in the past regarding the real determination of this species, it is not possible to be certain of its distribution, but it is probable that it occurs in the Pacific Ocean off the Californian coast (Esterly) and between lat. 13° N.–3° S., long. 87°–132° W. (Giesbrecht), off New Zealand and on the Australian Barrier Reefs (Farran) and from the Malay Archipelago (A. Scott). In the Indian Ocean from the Nicobar Islands (Sewell), the Arabian Sea (Thompson and A. Scott, present record), the Red Sea (Cleve, A. Scott) and the east coast of Africa (Thompson); in the Atlantic Ocean (Cleve, Wolfenden), the east coast of North America, Woods Hole (Wilson), and in the St. Lawrence River (Herdman, Thompson and A. Scott), in the English Channel (Norman and T. Scott, Farran), and in the Mediterranean Sea (Giesbrecht, Steuer, Pesta). If the form recorded by Giesbrecht (1902) from the "Belgica" collections is correctly

referred to this species, it is also to be found in the Antarctic Ocean (Giesbrecht, Farran). In the Arctic region it is replaced by *O. borealis* Sars.

Oncœa media Giesbrecht.

Oncœa media, Giesbrecht, 1892, p. 591, pl. ii, fig. 12, pl. xlvii, figs. 1, 11, 29–33, 40; van Breemen, 1908, p. 187, fig. 200.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, several examples.

Descriptive Notes.—The females of this species appear to fall into two definite size-groups, which I term f. *major* and f. *minor* respectively.

Giesbrecht himself (1892, p. 593) has called attention to the great range in length of individuals of this species, namely, from 0·55 mm. to 0·82 mm., and remarks that the small examples were very rare. In the present collection the small specimens are considerably more rare than those of larger size, but I have failed altogether to discover any intermediate examples that would link the two forms together, the two groups being quite distinct without any overlapping.

forma *major*.

♀. Total length ranging from 0·733 mm. to 0·817 mm., with a mean of 0·7745 mm. Giesbrecht (*loc. cit.*, p. 593) gives the length as ranging from 0·55 to 0·82 mm. The proportional lengths of the anterior and posterior regions of the body are as 63 to 37. The proportional lengths of the segments of the posterior region are as follows:

Segment.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	11	53	8	6	8	14 = 100

The furcal rami are one and three-fourths times the length of the anal segment and are about two and a half times as long as broad. The anal segment and the furcal rami are in most examples covered with stout chitin, which in some instances is stained a rich orange-red colour.

In the 1st antenna the various segments have the following proportional lengths:

Segment 1.	2.	3.	4.	5.	6.
14	24	37	10	5	10 = 100

Giesbrecht gives the lengths in his examples as 5, 10, 15, 4, 1, 4, which, when calculated as parts per 100, gives 13, 26, 38, 10, 3, 10.

In the maxilliped the two spines arising from the 2nd basal segment are subequal and are of moderate length, as in *O. venusta*.

The swimming legs are as figured. In the 4th leg the terminal spine arising from the endopod appears to be distinctly longer than is figured by Giesbrecht, the spine being as much as two-thirds the length of the segment, whereas Giesbrecht figures it as only about half that length.

forma *minor*.

♀. The total length ranges from 0·58 mm. to 0·65 mm., with an average length of

0·612 mm. The proportional lengths of the various segments of the posterior region of the body are as follows :

Segment.	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
	11	51	8	6	9	15 = 100

In this form the furcal rami appear to be somewhat more slender than in f. *major*, and are nearly three times as long as broad.

The proportional lengths of the segments of the 1st antenna are as follows :

Segment 1.	2.	3.	4.	5.	6.
14	25	37	10	4	10 = 100

The mouth parts appear to be exactly similar to those of f. *major*.

I have been unable to detect any differences in the legs from those of f. *major*.

♂. The total length ranges from 0·533 mm. to 0·683 mm. This is a considerably greater range than that given by Giesbrecht (1892, p. 599), who states that his examples measured from 0·6 to 0·63 mm. The present examples, while too few to give a definite picture, appear to indicate the possibility that there are two groups, corresponding to the two female groups ; the majority of the specimens form a compact group, in which the length ranges from 0·533 mm. to 0·617 mm., with an average length of 0·574 mm., but six other examples appear to suggest a second group, in which the length ranges from 0·633 mm. to 0·683 mm., with an average length of 0·658 mm.

Remarks.—Several specimens, belonging to both f. *major* and f. *minor*, are infected with a parasitic Peridinian that appears to resemble *Blastodinium mangini* Chatton (1920, p. 161).

Distribution.—In the east Pacific Ocean between lat. 5° and 10° N., long. 99° to 115° W. (Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran), in the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean off the Nicobar Islands (Sewell), on the Ceylon Pearl Banks (Thompson and A. Scott), in the Bay of Bengal (T. Scott), in the Laccadive Sea (Thompson and A. Scott), in the Maldive and Laccadive Archipelagos (Wolfenden), the Arabian Sea (Thompson and A. Scott, present records), the Red Sea (T. Scott, Thompson and A. Scott), off the east coast of Africa (T. Scott). In the Antarctic as far south as Ross Island, " if no mistake has occurred " (Farran). In the Atlantic Ocean in the Brazilian current (Farran), the tropical Atlantic (Farran, T. Scott, Wolfenden), the North Temperate Atlantic (Thompson and A. Scott, T. Scott, Cleve), the Bay of Biscay (Farran), in the Mediterranean Sea (Giesbrecht, Thompson and A. Scott, Steuer, Pesta, Gurney) and round the British Isles (Norman and T. Scott, Pearson).

Oncœa mediterranea Claus.

Oncœa mediterranea, Giesbrecht, 1892, p. 591, pl. iv, figs. 4, 16, pl. xlvii, figs. 8–10, 47 ; van Breemen, 1902, p. 187, fig. 199.

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, surface, a few examples.

Distribution.—Tropical region of the East Pacific (Giesbrecht), off New Zealand and on the Great Barrier Reef (Farran), the Malay Archipelago (Cleve). In the Indian Ocean it has been taken in Nankauri Harbour, Nicobar Islands (present record), the Bay

of Bengal (T. Scott), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott), the Gulf of Aden and the Red Sea (Thompson and A. Scott), the Arabian Sea (Cleve, Thompson and A. Scott), off the east coast of Africa (T. Scott), round Cape Colony (Cleve). In the Atlantic Ocean it has been recorded from the South Atlantic (Wolfenden), the tropical Atlantic (Wolfenden, Farran), the North Atlantic (Wolfenden, Rose), the Mediterranean Sea (Claus, Thompson and A. Scott. Cleve, Früchtl, Pesta, Steuer) and off the British Isles (Pearson).

Oncœa venusta Philippi.

Onceœ venusta, Giesbrecht, 1892, p. 602, pl. ii, fig. 5, pl. iii, fig. 7, pl. xlvii, figs. 2, 5, 13, 17, 39, 44, 50, 54, 58.
Oncœa venusta, var. *venella*, Farran, 1929, p. 284, fig. 33.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 2000–0 m., 19 females, 3 males.

Sta. 61 C, Northern area of Arabian Sea, surface, numerous examples of both sexes.

Sta. 96, Central area of Arabian Sea, 10 m., 2 females.

Sta. 145 D, Maldive area, 50–0 m. vertical, 1 female, 13 males.

Descriptive Notes.—Farran (1929, p. 284, fig. 33) has called attention to the existence of two forms of this species, differing in the main in size. The smaller form he has termed *venella*. Both forms are present at Sta. 61.

forma *typica*.

♀. Total length 1·185–1·250 mm. The proportional lengths of the anterior and posterior regions of the body are as 59 to 41, and the length and breadth of the anterior region are as 59 to 29. The proportional lengths of the segments of the posterior region are given below :

Segment	Th. 5.	Abd. 1–2.	Abd. 3.	Abd. 4.	Abd. 5.	Furca.
f. *typica*	13	46	7	7	9	18 = 100
f. *venella*	13	43	7	8	9	20 = 100

The furcal rami are four times as long as broad.

forma *venella* Farran.

♀. Total length 0·85 to 0·91 mm. This is slightly smaller than the examples from New Zealand, which, according to Farran, measure 0·92 to 1·07 mm., but agrees with the specimens from the Australian Barrier Reef, which measured 0·84 to 0·91 mm. Farran (1936) states that in the collections from the Great Barrier Reefs there was no clear cut separation either of form or size, but in the present specimens there is a clear gap in the length measurements of the two groups. The proportional lengths of the anterior and posterior regions of the body are as 60 to 40, and the length and breadth of the anterior region are 60 to 24. The proportional lengths of the segments of the posterior region are given above and differ slightly from those of f. *typica*, the genital segment being slightly shorter and the furcal rami slightly longer. The proportions of the furcal rami are as 23 to 6.

Remarks.—It seems possible that these two forms have a slightly different breeding

season, for in f. *typica*, out of a total of 84 specimens examined, 12, or 14 per cent., were ovigerous, and 5 others were bearing spermatophores ; whereas in f. *venella*, examples of which were less common, out of a total of 23 specimens, only 1, or 4·4 per cent., was ovigerous and 1 other bore spermatophores. Examples of both the f. *typica* and f. *venella* were found to be infected with a parasitic Peridinian, apparently *Blastodinium mangini* Chatton (1920).

Distribution.—f. *typica* : The western half of the Pacific Ocean, between lat. 20° N. and 4° S. (Giesbrecht) and between lat. 30° N. and 45° S. (Brady), off New Holland, New Guinea and the Philippine Islands (Brady), the Sulu Sea (Dana), New Zealand and the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A Scott), the Aru Archipelago (Früchtl). In the Indian Ocean from the Nicobar Islands (Sewell), the Bay of Bengal (Thompson), the Madras coast (Menon), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott), the Maldive region (Wolfenden, present record), the Arabian Sea (Thompson and A. Scott, present records), the Red Sea (Thompson, A. Scott, Thompson and A. Scott), the south-west region of the Indian Ocean (Thompson, Wolfenden), the Agulhas Current (Cleve), off Cape Colony (Cleve). In the Atlantic Ocean in the south temporate region (Farran, Wolfenden), in the Brazilian Current (Farran), the tropical Atlantic, the Gulf of Guinea (T. Scott, as *O. obtusa*), the north temperate Atlantic (van Breemen, Farran), off the Irish coast (Pearson), the east coast of North America, Woods Hole region and Chesapeake Bay (Wilson, Wheeler), in the St. Lawrence River (Herdman, Thompson and A. Scott), the Mediterranean Sea (Giesbrecht, Thompson, Thompson and A. Scott, Pesta, Rose).

f. *venella* : Off New Zealand and the Australian Barrier Reefs (Farran), the Arabian Sea (present record), the south temperate, tropical and north temperate regions of the Atlantic (Farran) and in the English Channel (Norman and T. Scott). It appears possible that this form does not occur in the Mediterranean Sea.

Family Sapphirinidæ.

Genus *Sapphirina* Thompson.

I have already (1932) called attention to the cutaneous glands in certain genera of marine Copepoda and especially in *Metridia*, *Pleuromamma*, *Lucicutia*, *Heterorhabdus*, *Hemirhabdus* and *Disseta*, in all of which there are numerous glands both on the segments of the body and on the appendages. A number of species in the first four of these genera are known to be phosphorescent (*vide* Giesbrecht, 1895). A similar property has been claimed for a species of the genus *Sapphirina*, but Giesbrecht does not accept this, and is of the opinion that what was thought to be phosphorescence was, in fact, the irridescence which is such a characteristic feature of the species of this genus. Sars (1913–18, p. 195) has suggested that the so-called " eyes " of the Corycæidæ may be luminous organs, and in a subsequent work (1919–21, p. 113) he makes the same suggestion for these organs in the genus *Sapphirina*. Without venturing to express any opinion regarding the possible luminescence of species of the genus *Sapphirina*, I would call attention to the presence in this genus of numerous cutaneous glands, that open on both dorsal and ventral aspects of the body, and in Text-figs. 68, a–c, I have indicated the arrangement of these pores in three species.

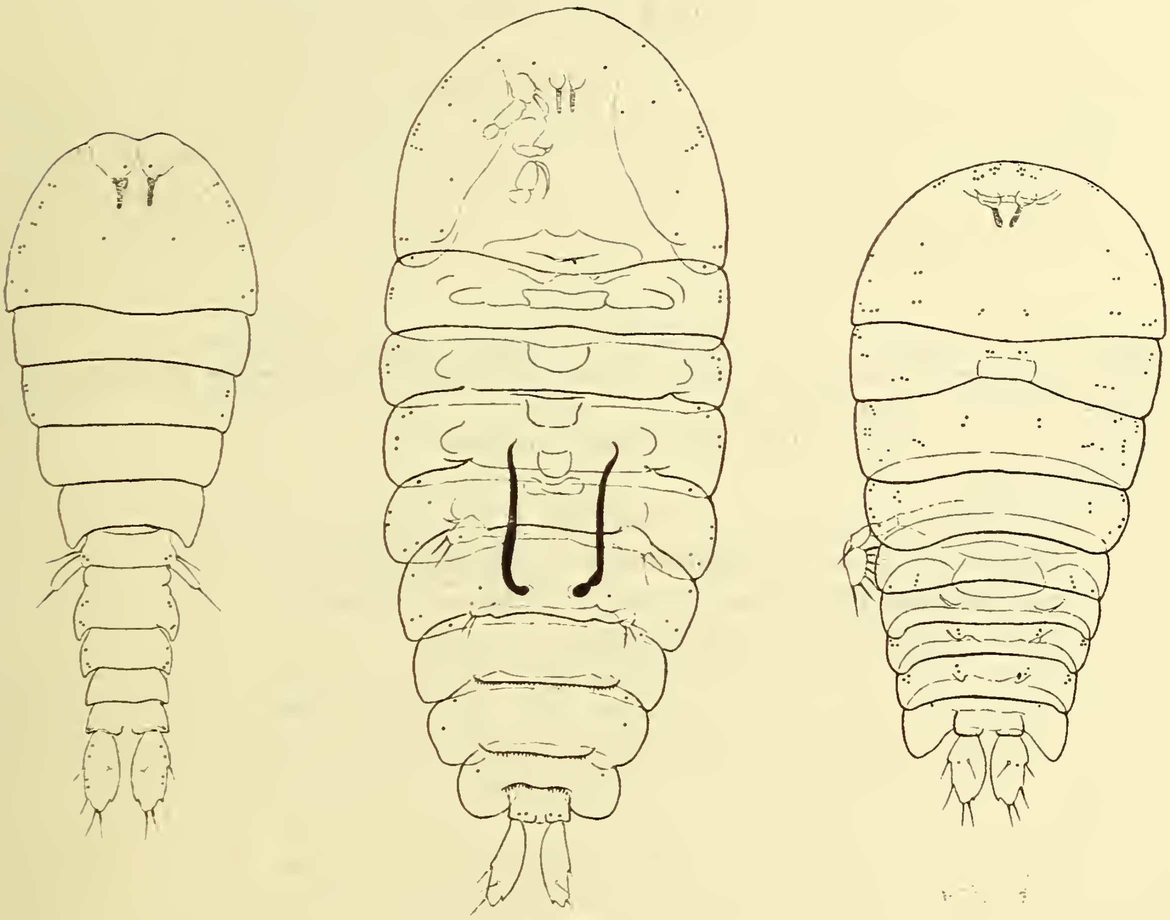
Sapphirina angusta Dana.

Sapphirina angusta, Giesbrecht, 1892, p. 620, pl. lii, figs. 5, 6, 20, 53, 55, 58, 66, pl. liii, figs. 6, 17, 29, 30, 55, pl. liv, figs. 2, 8, 17, 20, 60, 61 ; Lehnhofer, 1929, pp. 273, 315, figs. 1, 2, 47, 48.

Occurrence :

Sta. 96. Central area of Arabian Sea, 10 m., 1 female, 2 males ; 645–400 m., 2 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 18 specimens ; 1500–0 m., 15 males.



A B C

Text-fig. 68.—a, *Sapphirina ovatolanceolata* Dana, *gemma* Dana, ♀ : dorsal aspect. b, *Sapphirina iris* Dana, ♂, ventral aspect with the appendages removed. c, *Sapphirina nigromaculata* Claus, ♂, dorsal aspect.

Distribution.—In the Pacific Ocean from the Californian coast (Esterly), the central Pacific region (Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean from the southern area, lat. 43° S., long. 78° E. (Dana), the Arabian Sea (Cleve, present records), the south-west area, lat. 35° S., long 45° E. (Brady), and to the south of the Cape of Good Hope (Dana). In the Atlantic Ocean to the west of South Africa (Cleve), in the south temperate region (T. Scott) and off the east coast of the Argentine (Brady, as *S. opaca*), in the tropical region

(Wolfenden, T. Scott), the Gulf of Guinea (T. Scott, as *S. opaca*), the north temperate region (Lubbock, as *S. opaca*, Rose), in the Gulf Stream to the south of Nantucket (Wilson), and in the Mediterranean Sea (Haeckel, Giesbrecht, Steuer, Pesta, Rose).

Sapphirina bicuspidata Giesbrecht.

***Sapphirina bicuspidata*, Giesbrecht, 1892, p. 620, pl. lii, figs. 39–41, pl. liii, figs. 9, 37, 54, pl. liv, figs. 5, 30, 66 ; Lehnhofer, 1929, pp. 274, 317, figs. 3, 47, 49.**

Occurrence :

" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface.

Sta. 61 C, Northern area of Arabian Sea, surface, 1 female.

Distribution.—In the Pacific Ocean in the eastern tropical area (Giesbrecht), the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean off the Nicobar Islands (present record), the Laccadive Sea (Thompson and A. Scott), the Arabian Sea (present record) and the Red Sea (Steuer). In the Atlantic Ocean in the tropical region (Farran), and in the Mediterranean Sea (Giesbrecht, Steuer).

Sapphirina iris Dana.

***Sapphirina iris*, Sars, 1921, p. 114, pls. lxxv, lxxvi ; Lehnhofer, 1929, pp. 279, 323, figs. 9, 55.**
***Sapphirina salpæ*, Giesbrecht, 1892, p. 618, pl. ii, fig. 9, pl. lii, figs. 1, 2, 18, 19, 27, 45, 49, pl. liii, figs. 7, 23, 24, 60, pl. liv, figs. 9, 13, 19, 57.**
***Sapphirina longifurca*, A. Scott, 1909, p. 259, pl. lxix, figs. 15–20.**

Occurrence :

" Investigator " Sta. 632, Car Nicobar, Nicobar Islands, surface.

Sta. 42, South coast of Arabia, surface, 2 females, 1 male.

Sta. South coast of Arabia, surface, 31 females, 6 males.

Sta. 56, South coast of Arabia, surface, 1 male.

Remarks.—All these examples were of the " *longifurca* " type and were associated with examples of the aggregated form of the Salp *Pegea confœderata* ; a number of these Salps were collected and preserved in formalin solution, and subsequent examination of the bottle produced no less than 37 specimens, some free in the preserving solution, others still contained within the Salp.

Distribution.—In the east Pacific region (Giesbrecht), the coast of California (Esterly), the west coast of South America (Dana), the Philippine Islands and New Holland (Brady), off New Zealand (Brady, Farran), the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean from the Nicobar Islands (present record), the Bay of Bengal (Thompson), the Ceylon Pearl Banks (Thompson and A. Scott), south-west of Ceylon (Thompson), the Arabian Sea (Thompson and A. Scott, present records) and the Red Sea (?) (Steuer). In the Atlantic Ocean from the south temperate region (Brady, T. Scott), the tropical region (T. Scott), the north temperate region (Brady, Wolfenden, Rose), the Mediterranean Sea (Claus, Giesbrecht, Rose), and possibly, on occasion, the Norwegian coast (Sars).

Sapphirina metallina Dana.

***Sapphirina metallina*, Giesbrecht, 1892, p. 620, pl. liv, figs. 47–56 ; Lehnhofer, 1929, pp. 284, 325, figs. 16–18, 57, 58.**

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface.

Distribution.—In the Pacific Ocean in lat. 1° N., long. 173° E. (Dana), lat. 18° N., long. 117° E. (Brady), to the south of New Guinea (Brady), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve. A. Scott). In the Indian Ocean in the Nicobar Islands (present record), the Maldive Archipelago (Wolfenden), the Arabian Sea (Thompson and A. Scott). the Red Sea (Steuer). In the Atlantic Ocean in the tropical region (Brady, Wolfenden), the Gulf of Guinea (Lubbock, T. Scott), the north temperate region off the Canary Islands (Thompson) and in the Mediterranean Sea (Giesbrecht, Steuer, Pesta, Rose). Wolfenden (1911) has recorded this species from the Antarctic Ocean.

Sapphirina nigromaculata Claus.

Sapphirina nigromaculata, Giesbrecht, 1892, p. 619, pl. lii, figs. 32, 35, 43, pl. liii, figs. 13, 26, 36, 48, pl. liv, figs. 6, 37, 40, 68 : Lehnhofer, 1929, pp. 304, 336, figs. 38–41, 65, 66.

Occurrence :

"Investigator" Sta. 614, Nankauri Harbour, Nicobar Islands, surface.

Sta. 61 C, Northern area of Arabian Sea, surface, 5 females, 3 males.

Sta. 96, Central part of Arabian Sea. 10 m.. 1 female. 2 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 1 female, 1 male.

Distribution.—In the tropical Pacific Ocean (Giesbrecht), and perhaps from the Philippine Islands (Brady, as *S. inæqualis*), the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean from the Nicobar Islands (present record), the Bay of Bengal (Thompson), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott), the Maldive area (Thompson and A. Scott, Wolfenden), the Arabian Sea (Cleve, Thompson and A. Scott, Pesta, present records), the Red Sea (Giesbrecht, Cleve), the east coast of South Africa off Port Shepstone (Cleve) and the south-west region of the Indian Ocean (Thompson). In the Atlantic Ocean from the tropical region (Cleve, Farran, Wolfenden) and off Rio de Janeiro in the Brazilian Current (Farran). the north temperate region (Rose). off the Canary Islands (Thompson, as *S. inæqualis*), off the east coast of North America, south of Martha's Vineyard (Wilson) and in the Mediterranean Sea (Claus. Haeckel. Cleve. Steuer, Pesta. Rose).

Sapphirina opalina Dana—*darwini* Haeckel.

Sapphirina opalina, Giesbrecht, 1892, p. 620, pl. lii, figs. 44, 46, 52, 54, pl. liii, figs. 4, 22, 34, 56, pl. liv, figs. 3, 32, 33, 64.

Sapphirina opalina-darwinii, Lehnhofer, 1929, pp. 295, 330, figs. 29–32, 61, 62.

Occurrence :

"Investigator" Sta. 614, Nankauri Harbour, Nicobar Islands, surface.

"Investigator" Sta. 670, lat. 5° 56′ N., long. 76° 22′ E., surface.

Sta. 96, Central area of Arabian Sea, 645–400 m., 22 females, 13 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 5 males ; 1500–0 m., 4 males.

Sta. 145 D, Maldive area, 50–0 m., vertical, 1 female.

Distribution.—In the Pacific Ocean from the Gulf of Panama and the west Pacific region (Giesbrecht). off the Philippine Islands (Brady). off New Zealand and from the Australian Barrier Reefs (Farran). the Malay Archipelago (A. Scott). In the Indian Ocean

from the Nicobar Islands (present records), the Laccadive Sea (present record), the Maldive area (Wolfenden, present record), the Arabian Sea (Cleve, present record), the Red Sea (Steuer) and to the east of South Africa (Cleve). In the Atlantic Ocean from the Gulf of Guinea (T. Scott), the tropical region (Lubbock, Dana, Cleve, Wolfenden, T. Scott), off Rio de Janeiro in the Brazilian Current (Farran), the Carribean Sea (Cleve), off the Azores (Rose) and in the Mediterranean Sea (Claus, Haeckel, Thompson, Steuer, Pesta).

Sapphirina ovatolanceolata Dana—*gemma* Dana.

Sapphirina ovatolanceolata, Giesbrecht, 1892, p. 620, pl. i, figs. 7, 8, pl. lii, figs. 21, 25, 26, 47, 56, 65, 67, pl. liii, figs, 2, 18, 20, 25, 28, 58, pl. liv, figs. 1, 18, 42, 45.
Sapphirina gemma, Giesbrecht, 1892, p. 620, pl. lii, figs. 22, 62, 64, pl. liii, figs. 19, 31, 32, 61, pl. liv, figs. 10, 12.
Sapphirina ovatolanceolata-gemma, Lehnhofer, 1929, pp. 298, 333, figs. 33–37, 63, 64.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface, 7 females ; 1000–0 m., 1 male.
Sta. 61 C, Northern area of Arabian Sea, surface, 2 females.
Sta. 96, Central area of Arabian Sea, 10 m., 2 females ; 645–400 m., 1 male.
Sta. 131 D, Southern area of Arabian Sea, vertical, 500–0 m., 6 specimens ; 1500–0 m., 3 males.

Remarks.—The total length of the males ranged from 3·283 to 3·583 mm. and of the females from 2·40 to 2·767 mm.

These examples belong to the *ovato-lanceolata* form.

Distribution.—In the Pacific Ocean from the eastern region (Giesbrecht, Dana), off New Zealand (Dana, Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (A. Scott). In the Indian Ocean from the south-east temperate region (Lehnhofer), the Bay of Bengal (Lehnhofer), the Ceylon Pearl Banks (Thompson and A. Scott), the Arabian Sea (Cleve, Thompson and A. Scott, present records) and from the region to the south of the Cape of Good Hope (Dana), the Red Sea (Cleve, Thompson and A. Scott). In the Atlantic Ocean in the West Wind Drift (Lehnhofer), in the Benguela Current (Cleve, Wolfenden, Lehnhofer), the Gulf of Guinea (Lubbock), in the tropical region (Lubbock, Giesbrecht, Cleve, Wolfenden, T. Scott), in the Brazilian Current (T. Scott), the north temperate region (Farran), the east coast of North America to the south of Martha's Vineyard (Wilson), in Chesapeake Bay (Wilson), the Gulf Stream south of Nantucket (Wheeler) and in the Mediterranean Sea (Thompson, Giesbrecht, Steuer, Pesta, Rose).

Sapphirina sinuicauda Brady.

Sapphirina sinuicauda, Giesbrecht 1892, p. 620, pl. lii, fig. 31, pl. liii, figs. 42, 50, pl. liv, figs. 26, 36, 70.
Sapphirina auronitens-sinuicauda, Lehnhofer, 1929, pp. 289, 329, figs. 22–28, 50, 60.

Occurrence :

" Investigator " Sta. 670, lat. 5° 56′ N., long, 76° 22′ E., surface.
Sta. 61 C, northern area of Arabian Sea, surface, 1 female, 1 male.

Distribution.—In the Pacific Ocean from the east area and central region of the tropical belt (Giesbrecht), from the Philippine Islands (Brady) and the Malay Archipelago (A. Scott). In the Indian Ocean from the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (present record), the Arabian Sea (present record), the Red Sea

(Steuer), and the east coast of Natal (Cleve). In the Atlantic Ocean from the west of South Africa (Cleve), the Gulf of Guinea (T. Scott), off the Azores (Cleve, Rose) and in the neighbourhood of the American coast (Rose) and in the Mediterranean Sea (Lehnhofer, Rose).

Sapphirina stellata Giesbrecht.

Sapphirina stellata, Giesbrecht, 1892, p. 620, pl. lii, figs. 7–9, pl. liii, figs. 15, 35, 59, pl. liv, figs. 22, 27, 69; Lehnhofer, 1929, pp. 286, 327, figs. 19, 20, 52, 59.

Occurrence:

"Investigator" Sta. 614, Nankauri Harbour, Nicobar Islands, surface.
"Investigator" St. 670, Indian Ocean, lat. 5° 56′ N., long. 76° 22′ E., surface.
Sta. 61 A, Northern area of Arabian Sea, surface, 2 females.
Sta. 61 C, Northern area of Arabian Sea, surface, 1 female.

Distribution.—In the east Pacific region in the tropical belt (Giesbrecht), at several stations in the western region (Brady), off the Australian Barrier Reefs (Farran) and in the Malay Archipelago (Carl, A. Scott). In the Indian Ocean in the south-east region off the Abrolhos Islands (Giesbrecht), off the Nicobar Islands (present records), the Arabian Sea (Cleve, Lehnhofer), the Persian Gulf (Pesta) and in the south-west region (Thompson). In the Atlantic Ocean from the neighbourhood of the American Coast (Rose). Under the name *S. ovalis* this species was recorded by Brady from the tropical Atlantic Ocean, as well as from the central and western parts of the Pacific Ocean, and by T. Scott from the Gulf of Guinea and the tropical Atlantic, but the occurrence of the species in the Mediterranean Sea, as recorded by Thompson (1888) under the name *S. ovalis*, appears to be open to doubt.

Genus *Copilia* Dana.

Copilia hendorffi Dahl.

Copilia hendorffi, Lehnhofer, 1926, pp. 129, 138, text-fig. 8, 1–8, text-fig. 15, 1–7.

Occurrence.—Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 1 male.

Distribution.—In the Pacific Ocean off New Zealand (Farran). In the Indian Ocean in the southern area (Lehnhofer), the Arabian Sea (present record), and in the contra-equatorial current (?) (Lehnhofer); off Cape Colony and in the south-east part of the Atlantic Ocean (Lehnhofer).

Copilia lata Giesbrecht.

Copilia lata, Giesbrecht, 1892, p. 648, pl. l, fig. 40; Lehnhofer, 1926, pp. 132, 141, text-fig. 11, 1–4, text-fig. 17, 1–6.
Copilia elliptica, ♂, Giesbrecht, 1892, p. 648, pl. l, figs. 3, 35.

Occurrence.—Sta. 96, Central area of Arabian Sea, 10 m., 10 females; 645–400 m., 2 females, 1 male.

Distribution.—In the Pacific Ocean in both east and west areas of the tropical zone (Giesbrecht), off the Australian Barrier Reefs (Farran). In the Indian Ocean in the south equatorial and contra-equatorial currents (Lehnhofer), the Arabian Sea (present records). In the Atlantic Ocean in the south temperate region and the Brazilian current (Giesbrecht),

in the tropical region (Wolfenden, Lehnhofer, Farran), in the Guinea current (Lehnhofer), and in the north temperate region (Dahl).

Copilia mediterranea (Claus).

Copilia denticulata, ♂, Giesbrecht, 1892, p. 647, pl. i, fig. 2, pl. l, figs. 2, 27, 28, 38, 43.
Copilia oblonga, ♀, Giesbrecht, 1892, p. 648, pl. l, fig. 31.
Copilia mediterranea, Lehnhofer, ♂, p. 127, text-fig. 6, 1–4; ♀, p. 137, text-fig. 14, 1–4.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1500–0 m., 6 males.
Sta. 61 C, Northern area of Arabian Sea, 1000–0 m., 6 males ; 1500–0 m., 8 males.
Sta. 76, Gulf of Oman, 200–0 m., 2 males.
Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., vertical, 1 male.
Sta. 145 C, Maldive area, 300–0 m., vertical, 3 males.
Sta. 145 D, Maldive area, 500–0 m., vertical, 2 males.

Distribution.—From both east and west Pacific region (Giesbrecht). In the Indian Ocean from Nankauri Harbour, Nicobar Islands (Sewell), the Bay of Bengal (T. Scott), the Arabian Sea and the Gulf of Oman (present records). In the Atlantic Ocean from the south temperate region (Wolfenden), (?) the Gulf of Guinea (T. Scott), the tropical Atlantic (Wolfenden, Lehnhofer), the north temperate Atlantic (Dahl, T. Scott, Lehnhofer) and the Mediterranean Sea (Pesta, Steuer, Früchtl, Rose). Lehnhofer has suggested that in the tropical region this species descends into deep water to avoid the heat of the surface water, and this seems to be borne out by the depths at which the majority of specimens were taken during the John Murray Expedition.

Copilia mirabilis Dana.

Copilia mirabilis, Giesbrecht, 1892, p. 647, pl. l, figs. 5, 7, 19, 34, 37, 42 ; Lehnhofer, 1926, pp. 125, 135, 143, text-fig. 4, 1–4, text-fig. 13, 1–5.
Copilia mirabilis, var. *platyonyx*, Lehnhofer, 1926, p. 127, text-fig. 4, 5–7, text-fig. 18.

f. *typica* Dana.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 3 males ; 1500–0 m., 5 males.
Sta. 61 C, Northern area of Arabian Sea, surface, 2 females, 2 males ; 1000–0 m., 23 males ; 1500–0 m., 38 males.
Sta. 76, Gulf of Oman, 200–0 m., 41 males ; 600–0 m., 14 males.
Sta. 96, Central part of Arabian Sea, 10 m., 19 females, 4 males ; 645–400 m., 8 males.
Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 1 female, 81 males ; 1500–0 m., vertical, 43 males.
Sta. 145 C, Maldive area, 50–0 m., vertical, 2 males ; 300–0 m., 1 female, 6 males ; 500–0 m., 1 male.
Sta. 145 D, Maldive area, 100–0 m., vertical, 13 males ; 500–0 m., 1 female, 5 males.
Sta. 172, Central part of Arabian Sea, 400–0 m., 1 female, 2 males ; 850–0 m., 12 males.

f. *platyonyx* Lehnhofer.

Occurrence :

Sta. 61 C, Northern area of Arabian Sea, 1500–0 m., 2 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 1 male.

Sta. 145 C, Maldive area, 300–0 m., vertical, 1 male.

Sta. 145 D, Maldive area, 50–0 m., vertical, 1 male ; 100–0 m., 4 males ; 300–0 m., 1 male ; 500–0 m., 2 males.

Distribution.—Throughout the tropical region of the Pacific Ocean in both east (Giesbrecht) and west (Dana, Giesbrecht), off the Gilbert Islands (Dana), off Fiji, Papua, Kei Islands and the Philippine Islands (Brady), off New Guinea and Java (Dahl), the Australian Barrier Reefs (Farran), the Japanese Sea (Marukawa) and the Malay Archipelago (Cleve, A, Scott). In the Indian Ocean from the Nicobar Islands (Sewell), the tropical region of the ocean (Lehnhofer, Wolfenden), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott), the Maldive area (Wolfenden, present records), the Arabian Sea (Giesbrecht, Thompson and A. Scott, present records), the Gulf of Oman (present records), the Red Sea (A. Scott, Thompson and A. Scott) and east of Cape Colony (Cleve). In the Atlantic Ocean in the south temperate region (Brady, Wolfenden), the tropical region (Lubbock, Brady, Wolfenden), the Gulf of Guinea (T. Scott), the north temperate region (Thompson), the east coast of North America, Nantucket (Wilson) and the Mediterranean Sea (T. Scott). Lehnhofer also doubtfully records a single specimen from the West Wind Drift in lat. 56° 30′ S. : long. 14° 29′ E.

The variety *platyonyx* has now been recorded from the Australian Barrier Reefs (Farran) ; the Maldive area and the Arabian Sea (present records), the Indian contra-equatorial current, off the east coast of Africa, the south equatorial current to the south-west of Sumatra ; and in the south equatorial current and the Guinea current in the Atlantic Ocean (*vide* Lehnhofer).

Copilia quadrata Dana.

Copilia quadrata, Giesbrecht, 1892, p. 647, pl. 1, figs. 1, 10, 13, 16, 22, 28, 33, 36, 41 ; Lehnhofer, 1926, pp. 130, 140, text-fig. 10, 1–4, text-fig. 16, 1–5.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, 1000–0 m., 1 male.

Sta. 61 C, Northern area of Arabian Sea, 1000–0 m., 8 males ; 1500–0 m., 2 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 1 female, 1 male.

Distribution.—In the Pacific Ocean both east and west in the tropical region (Dana, Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean in Nankauri Harbour, Nicobar Islands (Sewell), the tropical region (Lehnhofer), the Arabian Sea (present records), the south-west region of the Indian Ocean (Wolfenden), and off Cape Colony (Lehnhofer, T. Scott). In the Atlantic Ocean in the south temperate region (Wolfenden), in the tropical region (Wolfenden), the Gulf of Guinea (T. Scott), the North Atlantic (Farran) and the Mediterranean Sea (Steuer, Pesta, Rose).

Copilia vitrea (Haeckel).

Copilia vitrea, Giesbrecht, 1892, p. 647, pl. l, figs. 6, 12, 17, 18, 23–26, 30, 39, 44, 46, 47 ; Lehnhofer, 1926, p. .

Occurrence :

Sta. 61 C, Northern area of Arabian Sea, 1000–0 m., 2 males.

Sta. 131 D, Southern area of Arabian Sea, 500–0 m., vertical, 8 males ; 1500–0 m., 2 males.

Distribution.—In the west Pacific Ocean (Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran) and the Malay Archipelago (A. Scott). In the Indian Ocean in the south equatorial and contra-equatorial currents (Lehnhofer), the Arabian Sea (present records). In the tropical region of the Atlantic Ocean (Dahl, Giesbrecht, Wolfenden), in the Gulf of Guinea (T. Scott, Lehnhofer), in the north temperate region (Dahl, Lehnhofer) and in the Mediterranean Sea (Giesbrecht, Thompson).

Family Lichomolgidæ.

Genus *Pachysoma* Claus.

Pachysoma tuberosum Giesbrecht.

Pachysoma tuberosum, Giesbrecht, 1892, p. 615, pl. xlviii, fig. 37.

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface, 1 female.

Distribution.—In the Pacific Ocean in the Gulf of Panama (Giesbrecht), and the Australian Barrier Reefs (Farran) ; in the Indian Ocean in Nankauri Harbour, Nicobar Islands (present record), to the south-east of Ceylon in lat. 3° 30′ S., long. 83° 30′ E. (Cleve), and on the east of Cape Colony in the Agulhas current (Cleve).

Genus *Corycæus* Dana.

Sub-genus *Corycæus* M. Dahl.

M. Dahl (1912, p. 12) includes in this sub-genus *Corycæus speciosus* Dana, *C. crassiusculus* Dana and *C. vitreus* Dana. This last species was only known from the male until Farran (1936, p. 134) recorded what he believes to be the female from New Zealand and the Australian Barrier Reefs. The correct determination of the females of these three species is one of extreme difficulty, since almost the only features that have been used for their separation are the proportional lengths of the abdominal segments, and especially of the anal segment.

Corycæus (*Corycæus*) *crassiusculus* Dana. (Text-fig. 69, a–h.)

Corycæus elongatus, Claus, 1863, p. 157, pl. xxiv, figs. 3, 4 (*non C. elongatus*, Giesbrecht).
Corycæus danæ, Giesbrecht, 1892, p. 660, pl. li, figs. 59, 60.
Corycæus (*Corycæus*) *crassiusculus*, M. Dahl, 1912, p. 21. pl. iii, figs. 1–7.

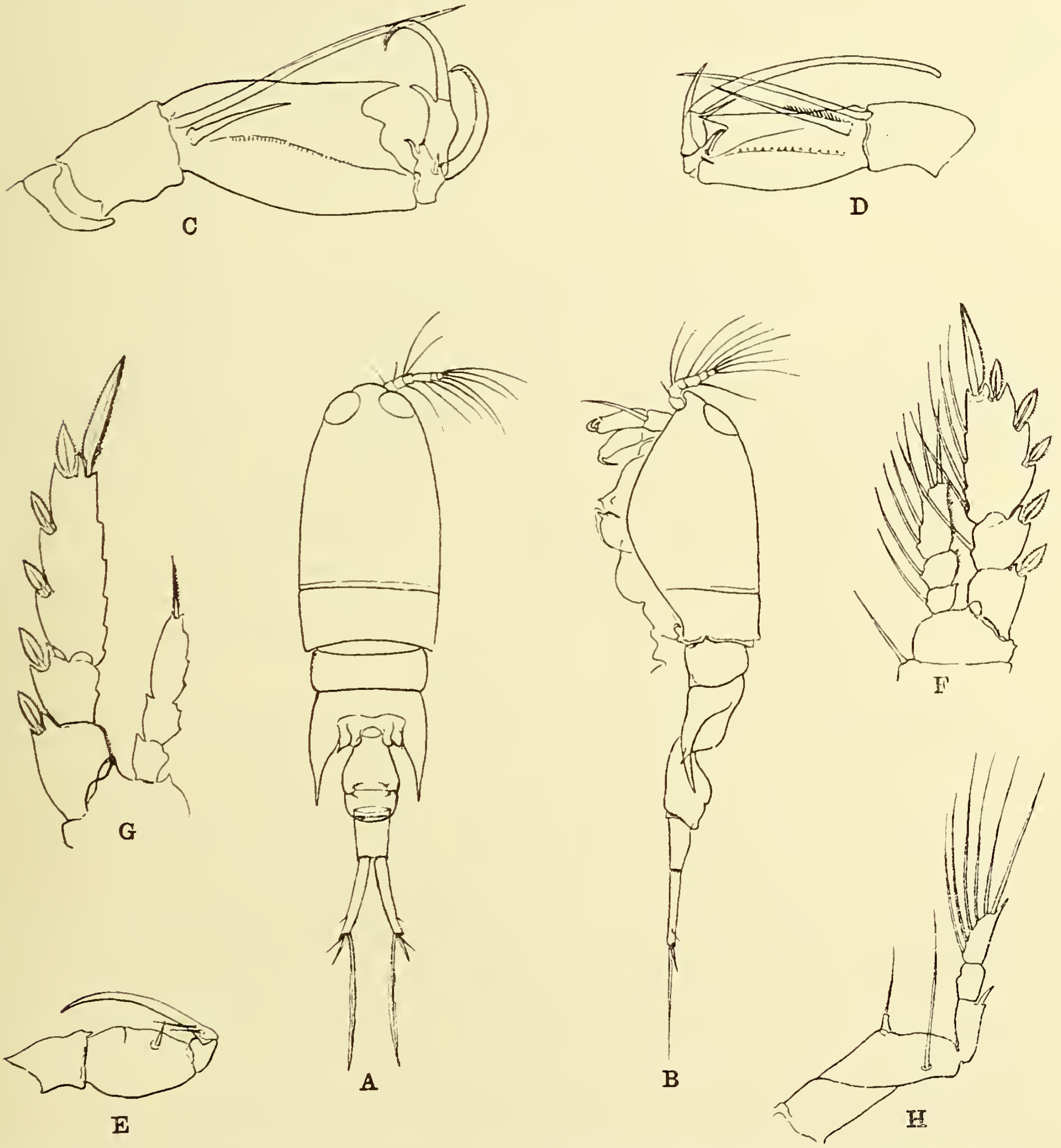
Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface, 12 females, 3 males.

Sta. 61 C, Northern area of Arabian Sea, surface, 8 females.

Descriptive Notes.—♀. The total length ranges from 1·60 to 1·717 mm., with a mean length of 1·647 mm. The proportional lengths of the anterior and posterior regions of the body are as 62 to 38. The proportional lengths of the various segments of the body are as follows :

	Cephalon & Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
(I)	466	52	73	16	166	93	134 = 1000
(II)	467	60	80	15	161	80	136 = 1000
(III)	472	50	80	16	156	90	136 = 1000
(IV)	483	63	70	26	149	74	135 = 1000



Text-fig. 69.—*Corycæus* (*Corycæus*) *crassiusculus*, A, Dana. Dorsal view, ♀. B, Lateral view, ♀. C, 2nd antenna, ♀. D, 2nd antenna, ♂. E, 2nd maxilla, ♂. F, 1st leg, ♀. G, 2nd leg, ♀. H, 4th leg, ♀.

The cephalon (Text-fig. 69, A, B,) and 1st thoracic segment are demarcated by a line that can be traced running across the dorsum and down to the lateral margin; the proportional lengths of the two parts are as 362 to 105 or 376 to 107. The genital segment is more pyriform than oval, as stated by M. Dahl, and overreaches the anal segment dorsally; it is armed with a row of minute spinules along the ventral part of the posterior margin. The anal segment tapers slightly, and the margins of the articulations of the furcal rami are fringed with small spinules. The furcal rami taper slightly towards the posterior end, and the distal margin is produced in a comb of small triangular spinules. The proportional lengths of the abdominal segments and the furcal rami in the present examples exhibit some degree of variation, as shown above, and the proportional dimensions of the anal segment also vary, the ratio of length to breadth at the base ranging from 1·39 to 1 to 1·27 to 1.

The proportional lengths of the six segments of the 1st antenna are as follows:

Segment 1.	2.	3.	4.	5.	6.
21	15	16	24	14	10 = 100

The antennal setæ are long and slender.

The 2nd antenna (Text-fig. 69, C) agrees closely with the figure given by M. Dahl for this appendage in *C. clausi* (*cf.* M. Dahl, 1912, pl. ii, fig. 7).

As regards the swimming legs, M. Dahl states that the three anterior pairs in this species are larger in proportion to the body than in *C. speciosus* Dana. I have carefully measured the length of these limbs in both species, and the proportional lengths of the appendages in specimens *of the same size* would be as follows:

	crassiusculus.	*speciosus.*
P. 1	31·2	30·0
P. 2	42·7	41·0
P. 3	39·2	40·0

The difference is thus so slight as to be negligible.

♂. Total length, 1·367 to 1·483 mm. The proportional lengths of the various segments of the body are as follows:

Cephalon & Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
466	46	79	23	159	79	148 = 1000

The 5th thoracic segment bears laterally two delicate setæ, the shorter about half the length of the longer. The 1st abdominal segment is armed ventrally on its posterior margin with a row of minute spinules; the genital aperture is armed with a short spinous process on the inner side of the seta, as in *speciosus*. The 2nd abdominal segment is also armed with a row of spinules along the articular margin of the furcal rami. The distal end of the furcal ramus is produced externally in a serrated crest.

Remarks.—M. Dahl (1912, p. 23) maintains that "the nearly related *clausi* is the Atlantic representative of *C. crassiusculus*." It seems to me, however, to be doubtful whether it is possible to differentiate between the females of these two, so-called species; Farran (1929, p. 292) states that the New Zealand specimens of what he then took to be

crassiusculus were intermediate between *C. clausi* and *C. crassiusculus* as regards the shape of the abdomen, but in a later paper he (1936, p. 134) suggests that these females are specimens of *C. vitreus*, the female of which was previously unknown. The present examples of the female appear to form a stage in a series of forms that display a gradual change in the proportions of the abdominal segments and the furcal rami. In the following table I have given the dimensions in parts per 100 of the length of these segments, recalculated from measurements in those instances in which such have been given by the authors and, where no measurements are stated, from measurements of the figures that illustrate the account. In this series I have included Claus' description and figure of *Corycæus elongatus*. Claus (1863, p. 157, pl. xxiv, figs. 3, 4) in his original account states quite clearly that the abdomen possesses two segments, "Das Abdomen in beiden Geschlechtern deutlich zweigliedrig," and this is clearly shown in his figure. Giesbrecht (1892, p. 666) was in error in stating that *elongatus* only has one segment, and, as M. Dahl (1912) has pointed out, he has confused in his account of what he took to be *elongatus* two species belonging to the sub-genus *Agetes*, viz. *typicus* and *limbatus*. A comparison of the figure given by Claus (1863, pl. xxiv, fig. 3) and fig. 69B appears to me to show without doubt that *elongatus* Claus must be grouped with *clausi* and *crassiusculus*, in the sub-genus *Corycæus*.

	Abdominal segments.			
	Abd. 1.	Abd. 2.	Furca.	
clausi (Atlantic)	47·2	22·2	30·6	(From Farran.)
elongatus (Messina)	46·5	16·7	36·8	(,, Claus.)
vitreus (Australia)	46·2	21·5	32·5	(,, Farran.)
clausi (Atlantic)	45·5	22·7	31·8	(,, M. Dahl.)
crassiusculus (New Zealand)	43·4	25·3	31·5	(,, Farran.)
,, (Arabian Sea)	42·2	23·6	34·1	Present examples.
,, (,, ,,)	41·6	20·7	37·7	
,, (Australia)	40·5	24·3	35·2	(From Farran.)
,, (Indo-Pacific)	38·5	23·0	38·5	(,, M. Dahl.)

It seems to be impossible to draw any hard and fast line of differentiation between the two forms *clausi* and *crassiusculus*, and it is preferable to regard them as two forms of a single species, namely, an Indo-Pacific form and an Atlantic form.

Distribution.—Widespread throughout the Pacific and Indian Oceans. In the Pacific it has been recorded from the eastern and central tropical areas (Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran), in the Aru Archipelago (Früchtl) and from the Malay Archipelago (Cleve, A. Scott). In the Indian Ocean it has been taken off Christmas Island (Farran), in the Bay of Bengal (Thompson), off the Madras coast (Menon, as *venustus* Dana), on the Ceylon Pearl Banks and in the Laccadive Sea (Thompson and A. Scott), the Arabian Sea (present records), the Red Sea (Cleve, Thompson, A. Scott, and Thompson and A. Scott), off the East African coast (Thompson), in the Agulhas current and off South Africa (Cleve, Wolfenden). M. Dahl (1912) maintains that it does not occur in the Atlantic Ocean, yet several authors, who have apparently correctly recorded its occurrence in Indian waters, have recorded it from the western region also, namely, from the South Atlantic in lat. 26–32° S. (T. Scott, as *venustus* Dana), the Gulf

of Guinea (T. Scott, as *venustus* Dana, lhe tropical Atlantic (Wolfenden), the North Atlantic (Cleve), the Woods Hole region (Wilson, as *danæ* Giesbrecht) and from the Mediterranean Sea (Thompson, Thompson and A. Scott, Rose or *elongatus* Claus).

Corycæus (*Corycæus*) *speciosus* Dana.

Corycæus speciosus, Giesbrecht, 1892, p. 673, pl. li, figs. 39, 40.
Corycæus (*Corycæus*) *speciosus*, M. Dahl, 1912, p.13, pl. i, figs. 1–13, pl. ii, figs. 1–4.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface, several examples.
Sta. 61 C, Northern area of Arabian Sea, surface, several specimens.

Descriptive Notes.—♀. The total length ranges from 1·75 to 1·98 mm., with a mean length of 1·903 mm. The proportional lengths of the various segments of the body are as follows :

Cephalon & Th. 1.	Th. 2.	Th. 3. Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
430	62	78	25	147	76	182 = 1000.

In a few examples the line of demarcation between the cephalon and the 1st thoracic segment can be seen as a fine line running across the middle of the dorsum, dividing this region into two segments, that have the proportional lengths of 333 and 97.

The posterior border of the genital segment on the ventral side is fringed with a row of minute spinules. The posterior margin of the 2nd abdominal segment, where the furcal rami are articulated, is also armed with a row of spinules. The furcal rami vary somewhat in length ; the distal border is produced in a small crest that is fringed with a series of small triangular pointed prominences. Of the two unequal spines that are carried by the furcal rami the longer is serrated.

The segments of the 1st antenna have the following proportional lengths :

Segment 1.	2.	3.	4.	5.	6.
21	14	16	26	13	10 = 100

In the 2nd antenna there appears to be an additional chitinous scute, that is, comma-shaped, lying between the cephalon and what is usually regarded as the 1st basal segment of the appendage ; the 3rd (usually termed the 2nd) basal segment is the longest, and bears on its outer aspect a longitudinal row of minute spinules.

The mouth parts appear to be as figured by M. Dahl (*loc. cit.*, 1912).

M. Dahl (*loc. cit.*, p. 16) gives a setal formula for the swimming legs, but this is somewhat misleading, as she includes as " spines " or setæ the small projections on the distal outer margins of certain segments of the endopods. The actual setal formula is as follows, the Roman numerals indicating spines and the Arabic numerals setæ :

	P. 1.						P. 2.						P. 3.						P. 4.		
	Exopod.			Endopod.			Exopod.			Endopod.			Exopod.			Endopod.			Exopod.		
	i.	ii.	iii.	i.	ii.	iii.	i.	ii.	iii.	i.	ii.	iii.	i.	ii.	iii.	i.	ii.	iii.	i.	ii.	iii.
Outer margin .	I	I	III, I	..	..	..	I	I	III, I	..	..	..	I	I	III, I	..	..	..	I	0	I, I
Inner margin .	0	1	4	1	1	4, 1	0	1	5	1	2	3, I	0	1	5	1	2	2	0	1	5

In the 1st leg the 3rd segment of the endopod bears 4 setæ on its inner margin, and from the distal end a seta-like spine arises between two small spinous projections. In the 2nd leg there are 3 setæ arising from the inner margin, and a spine, serrated on its outer border, springs from the distal margin between two spinous projections. In the 4th leg the 3rd segment of the exopod bears a single marginal spine at the distal outer angle, and from the distal extremity springs a long, tapering and seta-like spine, while 5 setæ arise from the inner margin.

♂. The total length ranges from 1·583 to 1·733 mm., with a mean length of 1·633 mm. The proportional lengths of the various segments of the body are as follows :

Cephalon & Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
419	44	85	15	148	93	196 = 1000

As in the female, the posterior margin of the 1st abdominal segment is armed with a row of small spinules on its ventral aspect.

Distribution.—This species has a wide distribution throughout the tropical and temperate regions of all three great oceans. It has been recorded in the Pacific from the west coast of America between lat. 10° S. and 20° N. (Giesbrecht), off New Zealand and the Australian Barrier Reefs (Farran), in the Aru Archipelago (Früchtl) and in the Malay Archipelago (A. Scott). In the Indian Ocean it has now been taken off Christmas Island (Farran), in the Nicobar Islands (Sewell), the Bay of Bengal (Thompson), the Ceylon Pearl Banks (Thompson and A. Scott), the Laccadive Sea (Thompson and A. Scott), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Cleve, Thompson and A. Scott, present record), the Gulf of Aden and Red Sea (Cleve, Thompson and A. Scott), the east coast of Africa (Thompson), and in the Agulhas current off South Africa (Stebbing). It has also been recorded from the Suez Canal by Thompson and A. Scott, but Gurney (1927*a*, p. 161) regards this as improbable. In the Antarctic Ocean off Kaiser Wilhelm II Land (Wolfenden). In the Atlantic Ocean it is known from the Gulf of Guinea (T. Scott), the South Atlantic (Giesbrecht, T. Scott), in the Brazilian current (Cleve), in the tropical Atlantic (Dana, Brady, T. Scott, M. Dahl), in the North Atlantic (Thompson, T. Scott, M. Dahl, Rose, van Breemen), on the east coast of North America, Chesapeake Bay and Woods Hole region (Wilson), on the coast of Ireland (Pearson) and in the Mediterranean Sea (Giesbrecht, Thompson and A. Scott).

Sub-genus *Urocorycœus* M. Dahl.

Corycœus (*Urocorycœus*) *longistylis* Dana.

Corycœus longistylis, Giesbrecht, 1892, p. 674, pl. li, figs. 36, 37.
Corycœus (*Urocorycœus*) *longistylis*, M. Dahl, 1912, p. 42, pl. vi, figs. 6–13, pl. vii, figs. 1–3.

Occurrence :

Sta. 131 D, Southern area of Arabian Sea, 1500–0 m., 1 female, ovigerous.

" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, 14 m.

Descriptive Notes.—In the specimens from the Nicobar Islands there is a quite distinct line of demarcation between the cephalon and the 1st thoracic segment, and the 2nd thoracic segment presented the appearance along the posterior border of a fringe of very fine needle-like spinules.

The proportional lengths of the abdominal segments and the furcal rami are as 48 to 52 ; M. Dahl (1912, p. 43) gives the proportions in her examples as 102 to 120–125, or approximately 45 to 55. The genital segment is fringed posteriorly with a row of short needle-like spinules. According to M. Dahl (1912, p. 43) there is, on the hinder margin of the anal segment above the furcal ramus, on each side a small tooth ; in the Nicobar specimens the articular margins of the anal segment with furcal rami are armed with groups of spinules, usually four spines in a group.

Distribution.—The species is widely distributed throughout the Indo-Pacific Oceans ; it has been taken in the Western Pacific between lat. 37° S. and 30° N., off the Sandwich Islands (Hawaii), Fiji, New Guinea, the Australian coast, the Philippine Islands and the China Sea (Brady, as *varius*), between lat. 1°–5° N., long. 109°–115° W. (Giesbrecht), off New Zealand (Farran), the Australian Barrier Reefs (Farran), the Malay Archipelago (Cleve, A. Scott) ; in the Indian Ocean from Christmas Island (Farran), in the Nicobar Islands (present record), the Gulf of Manaar (Thompson and A. Scott), the Maldive and Laccadive Archipelagoes (Wolfenden), the Arabian Sea (Thompson and A. Scott, present record), the Gulf of Aden (Thompson and A. Scott), the Red Sea (T. Scott, Thompson and A. Scott) and the Gulf of Suez (Thompson and A. Scott). M. Dahl (1912) maintains that this species does not occur in the Atlantic Ocean, but this is open to doubt. The character of the 2nd antenna in the female is quite distinct, and the species has been recorded from the Gulf of Guinea (T. Scott, as *varius*), the tropical Atlantic between lat. 37° S. to 3° N. (Wolfenden), the North Atlantic between lat. 21° and 26° N. (T. Scott), and from the Mediterranean Sea in 35° N., 18° E. (T. Scott). While this last record is open to some doubt, since the collection was not made direct from the sea, but by straining the water from the ship's tanks, the position seems to be much too far to the west to be accounted for on the supposition that the specimens had been taken in the Red Sea and had lived in the tanks for a week, namely, from June 29th to July 4th.

Sub-genus *Ditrichocorycæus* M. Dahl.

As Gurney (1927, p. 161) has pointed out, the species of the genus *Corycæus* (*sensu lato*) are amongst the most difficult of all Copepods to discriminate ; and this seems to me to be particularly the case with species of the sub-genus *Ditrichocorycæus*. M. Dahl (1912, p. 31) in her key to the species divides these into two groups according to the relative length of the furcal ramus and the two abdominal segments. In the first group she places those species in which the rami are short, *i.e.* not, or only slightly, longer than the anal segment and not two-thirds as long as the genital segment ; in this group fall *asiaticus*, *andrewsi* and *subtilis*. In the second group M. Dahl places those species in which the furcal rami are about twice as long as the anal segment or at least two-thirds as long as, or longer, than the genital segment ; to this group belong *amazonicus*, *anglicus*, *brehmi*, *africanus*, *dubius*, *erythræus*, *lubbocki*, *minimus* and *tenuis*. This latter group, so far as the females are concerned, can be subdivided into two smaller sub-groups by the presence or absence of a ventral hook on the anterior part of the genital segment ; such a hook is present in *africanus*, *amazonicus*, *anglicus*, *brehmi*, *dubius* and *erythræus*, but is absent in *minimus* and *tenuis* and, in my opinion, in the true *lubbocki* also. As regards this last species Giesbrecht (1892, p. 671) does not mention the presence of any such hook, and in his figure (pl. li, fig. 57) he clearly indicates that it is absent. F. Dahl (1894, p. 71) in a

footnote to his key remarks that it is not absolutely certain that the form which he identified as *lubbocki* is really Giesbrecht's species, since it possessed a ventral spine. M. Dahl (1912, p. 61), however, ignores this difference and, stating that in *lubbocki* there is a ventral hook that is small and slightly bent, concludes that the form described by Farran (1911, p. 291, pl. xii, figs. 8, 9) under the name *tenuis* Giesbrecht is the same species. With this opinion I entirely disagree. The true *lubbocki* Giesbrecht, in which the ventral hook is absent, has been redescribed by Früchtl (1924, p. 96) under the name *farrani*. That the forms "*tenuis*" Farran (*non* Giesbrecht) and "*lubbocki*" M. Dahl (*non* Giesbrecht) are synonyms, as suggested by M. Dahl, is, I think, probable, and it remains to be seen whether these can be referred to any other species: it seems to me probable that they are both synonyms of *africanus* F. Dahl (*vide infra*, p. 280).

Considerable confusion appears to have arisen regarding the species *erythrœus* Cleve and *dubius* Farran. M. Dahl appears to regard both these as good species; Gurney (1927, p. 161), however, regards them as synonyms. As Farran (1911, p. 292) pointed out in his original description of *dubius*, there are certain differences between the two forms, and until further examples can be studied it seems best to regard them, as M. Dahl has done, as distinct. There seems little doubt that the form which Gurney obtained from the Suez Canal and identified as *erythrœus* Cleve is identical with Farran's *dubius*, but is probably not the same as Cleve's *erythrœus*. There is very little difference in the proportional lengths of the abdominal segments and the furcal ramus, as is clear from the following table, in which I have calculated these lengths in parts per 100 of the whole abdomen:

♀.	Abd. 1.	Abd. 2.	Furca.
erythrœus Cleve	31·25	31·25	37·5
	(1)	(1)	(1·2)
dubius Farran	29·17	31·94	38·89
	(21)	(23)	(28)
"*erythrœus*" Gurney	32·64	29·67	37·69
	(110)	(100)	(127)
♂.			
erythrœus Cleve	40·0	26·7	33·3
	(12)	(8)	(10)
dubius Farran (Dahl)	40·3	24·2	35·5
	(25)	(15)	(22)
"*erythrœus*" Gurney	41·83	24·04	34·13
	(174)	(100)	(142)

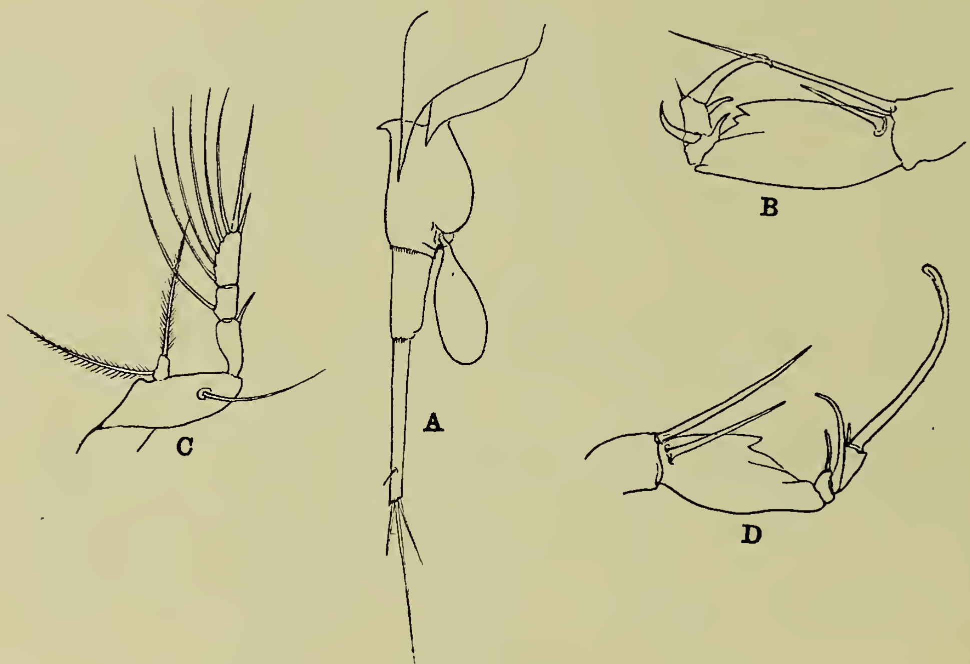
There are, however, appreciable differences in the 2nd antenna of the female; in *erythrœus* Cleve the spine arising from the 3rd basal segment is about half the length of that from basal 2, and reaches the distal margin of the segment, whereas in *dubius* Farran and "*erythrœus*" Gurney the 2nd basal spine is only about one-third the length of the 1st and reaches only half-way along the 3rd segment.

? *Corycœus* (*Ditrichocorycœus*) *africanus* F. Dahl. (Text-fig. 70, A–C.)

Corycœus (*Ditrichocorycœus*) *africanus*, M. Dahl, 1912, p. 62, pl. ix, figs. 8, 16, 24–29 and 32.
? *Corycœus* (*Ditrichocorycœus*) *lubbocki*, (pars) M. Dahl, 1912, p. 64, pl. x, figs. 20–28.
? *Corycœus tenuis*, Farran, 1911, p. 291, pl. xii, figs. 8, 9.

Occurrence.—" Investigator " Sta. 614, Nankauri Harbour, Nicobar Islands, surface, 1 female.

Descriptive Notes.—This single specimen agrees in many respects with the form that was described by Farran (*loc. cit.*) under the name *tenuis* Giesbrecht; as Farran pointed out, if he followed F. Dahl's key the form would be referred to *C. anglicus*, but differed from this species in several characters. M. Dahl (1912, p. 64) referred the form to *C. lubbocki* Giesbrecht, but I am convinced that she was wrong. Neither *C. tenuis* Giesbrecht nor the true *C. lubbocki* Giesbrecht possess a hook on the ventral aspect of the genital segment, whereas such a hook is present in *C. tenuis* Farran (*non* Giesbrecht), in *C. lubbocki* M. Dahl (*non* Giesbrecht), and in the present specimen that I have examined.



Text-fig. 70.—*Corycæus* (*Ditrichocorycæus*) *africanus* F. Dahl, ♀. A, Side view of last thoracic segment and abdomen. B, 2nd antenna. C, 4th leg. *Corycæus* (*Ditrichocorycæus*) *asiaticus* F. Dahl, ♂. D, 2nd antenna.

According to M. Dahl's key (1912, p. 53) the choice appears to lie between *africanus* F. Dahl and *brehmi* Steuer. In the following table I have given the proportional lengths of the abdominal segments, calculated in parts per 100 of the total abdominal length in these different forms:

	Abd. 1.	Abd. 2.	Furca.	
tenuis Farran (*non* Giesbrecht)	35	20	45	(dorsal).
	30·8	25·6	43·6	(ventral).
lubbocki M. Dahl (*non* Giesbrecht)	35·2	22·5	42·3	(dorsal).
Present specimen	35·5	22·1	42·4	(dorsal).
africanus F. Dahl	37·5	18·75	43·75	(dorsal).
	30·0	22·9	47·1	(ventral).

There is thus but little difference between these forms.

In the present specimen the 2nd antenna agrees closely with the description and figures of *africanus* F. Dahl (*cf.* M. Dahl, 1912, pl. ix, fig. 29), except that Dahl shows the proximal claw as arising from the distal end of the 3rd basal segment, which is clearly an error. The 1st basal spine is about three times the length of the 2nd. The 3rd basal segment terminates in two triangular prominences.

In the 4th swimming leg the endopod bears two setæ on which the proximal arises almost at right angles from the endopod (*cf.* M. Dahl, 1912, pl. ix, fig. 16).

Distribution.—According to M. Dahl, *africanus* is limited to the Atlantic Ocean and is a coastal form from the west coast of Africa. If, however, I am correct in referring the present example to this species, the distribution must be extended to the Indian Ocean, Nankauri Harbour, Nicobar Islands, and if Farran's specimens are also examples of the species, it occurs off Christmas Island.

Corycæus (*Ditrichocorycæus*) *asiaticus* F. Dahl. (Text-fig. 70, d.)

Corycæus murrayi, Farran, 1911, p. 294, pl. xiii, figs. 1–6.
Corycæus (*Ditrichocorycæus*) *asiaticus*, M. Dahl, 1912, p. 74, pl. xi, figs. 1–9.

Occurrence.—Sta. 56. Southern area of Arabian coast, surface, 2 males.

Distribution.—This species appears to be confined to the Indo-Pacific region. It has been recorded from New Zealand (Kramer, as *auklandicus*), the Aru Archipelago (Früchtl), the Australian Barrier Reefs (Farran) and the Banda Straits (M. Dahl) in the Pacific: and in the Indian Ocean from near Sumatra in lat. 4° 56′ N., long 95° 16′ E., Christmas Island (Farran, as *murrayi*), the central area of the Indian Ocean in lat. 9° S., long. 65° E. (M. Dahl), the Arabian Sea (present record), the Suez Canal (Gurney) and off Zanzibar (M. Dahl).

Corycæus (*Ditrichocorycæus*) *lubbocki* Giesbrecht. (Text-fig. 71, a–f).

Corycæus lubbocki, Giesbrecht, 1892, p. 660, pl. li, figs. 57, 58.
? *Corycæus* (*Ditrichocorycæus*) *lubbocki*, M. Dahl, 1912, p. 64, pl. x, figs. 20–28.
Corycæus (*Ditrichocorycæus*) *farrani*, Früchtl, 1929, p. 96, figs. 72, 73.

Occurrence.—Sta. 56. Southern coast of Arabia, surface, 1 female.

Descriptive Notes.—♀. Total length 1·033 mm. The proportional lengths of the anterior and posterior regions of the body are as 56 to 44. Früchtl (*loc. cit.*) gives the length of the posterior region as 74·3 per cent. of the anterior region (or 57 to 43). The proportional lengths of the various segments are as follows:

Cephalon.	Th. 1.	Th. 2.	Th. 3.	Th. 4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
364	69	33	47	59	18	153	62	195 = 1000

The cephalon and 1st thoracic segment are separate. The 3rd thoracic segment is produced in a long stout spinous process that extends to half the length of the genital segment. The 4th thoracic segment is produced backwards and ends in a sharp spine.

Früchtl (*loc. cit.*, p. 96) gives the lengths of the segments of the posterior region as 129, 74, 170; I have recalculated these measurements as parts per 100 of the total

abdominal length and the result is 35, 20, 45 ; but a comparison of these measurements and his figure reveals certain differences, and if one takes the lengths of the several parts measured along the dorsal margin, the resulting proportional lengths come to 38, 16, 46, which agree very closely with the measurements observed by Giesbrecht and myself.

	Genital segment.	Anal segment.	Furcal ramus.	
Giesbrect	37	17	46	= 100
Früchtl	38	16	46	= 100
Present specimen	37	15	48	= 100

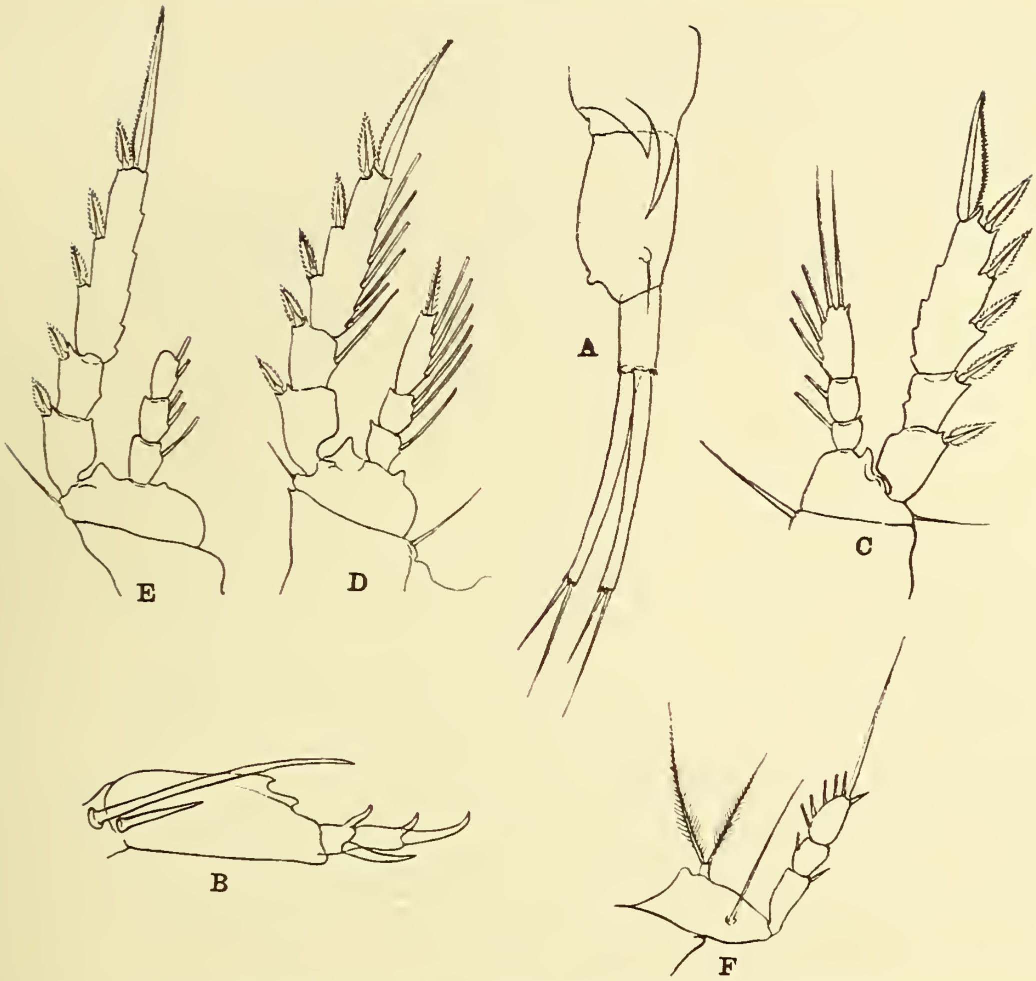
The genital segment (Text-fig. 71, A) is produced in a rounded eminence at the antero ventral region, but I have been entirely unable to detect any spinous projection in this region, such as is described and figured by M. Dahl; in this respect this example agrees with the figures given by Giesbrecht (1892, pl. li, fig. 57) and Früchtl (1924, fig. 72). The small rounded prominence on the dorsal aspect between the genital openings is present. The long furcal rami have a slight upward bend, as figured by Früchtl (*loc. cit.*, fig. 72).

The swimming appendages exhibit the following proportional lengths in their various segments, and for convenience of reference I have given the lengths as calculated from the measurements given by Früchtl (*loc. cit.*, p. 97).

P. I	Exopod 1	17	..
	,, 2	13	..
	,, 3	38	38.5 (Früchtl).
	Endspine	32	31·5 (,,).
P. II	Exopod 1	18·5	..
	,, 2	12	..
	,, 3	38·5	37·8 (Früchtl).
	Endspine	31	31 (,,).
P. III	Exopod 1	18	..
	,, 2	12	..
	,, 3	37	37 (Früchtl).
	Endspine	33	33 (,,).
P. IV	Exopod 1	19	..
	,, 2	11	..
	,, 3	16	..
	Endspine	54	..

The endspine of the exopod of the 2nd leg is slightly curved inwards.

Distribution.—Apparently confined to the Indo-Pacific region: off Hong Kong (Giesbrecht), the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl), the Ceylon Pearl Banks and Arabian Sea and Red Sea (Thompson and A. Scott), the Arabian Sea (present record) and the Red Sea (Cleve). As Gurney (1927, p. 161) has pointed out, the record of occurrence of this species in the Mediterranean Sea is probably an error, due to confusion of this species with *Corycæus* (*Ditrichocorycæus*) *brehmi* Steuer.



TEXT-FIG. 71.—*Corycæus* (*Ditrichocorycæus*) *lubbocki* Giesbrecht, ♀. A, Last thoracic segment and abdomen, lateral view. B, 2nd antenna. C, 1st leg. D, 2nd leg. E, 3rd leg. F, 4th leg.

Sub-genus *Onychocorycæus* M. Dahl.

In this sub-genus M. Dahl (1912, p. 82) includes the following species :

agilis Dana (= *gracillicaudatus* Giesbrecht).
giesbrechti F. Dahl (= *venustus* Esterly, *non* Giesbrecht).
latus Dana.
catus F. Dahl.
ovalis Claus.
pacificus F. Dahl.
pumilus M. Dahl.

And to these must be added *medius* Gurney (1927, p. 165, fig. 26), if this is a true species. Of these, *catus*, *pacificus* and *pumilus* are stated by M. Dahl to be Indo-Pacific forms, and closely related to these is *ovalis*, that she regards as a purely Mediterranean species. These four form a very closely related group that can be subdivided by the presence or absence of a ventral projection on the anterior part of the genital segment of the male, such a projection being present in *catus* and *pumilus* and absent in *pacificus* and *ovalis*.

Corycæus (*Onychocorycæus*) *agilis* Dana.

Corycæus (*Onychocorycæus*) *agilis*, M. Dahl, 1912, p. 84, pl. xii, figs. 10–20.
Corycæus gracilicaudatus, Giesbrecht, 1892, p. 660, pl. li, figs. 15, 30 ; Farran, 1911, p. 290, pl. xi, figs. 11, 12.

Occurrence :

Sta. 56, South Arabian coast, surface, 10 females, 23 males.

Sta. 61 C, Northern area of Arabian Sea, surface, several examples of both sexes.

Remarks.—These examples are slightly larger than those described by M. Dahl. The females average 1·00 mm. in total length, and the males 0·75 mm.

The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3–4.	Abd. 1.	Abd. 2.	Furca.
332	98	43	78	144	125	180 = 1000

The two furcal rami are in several instances of unequal length, the left being the longer in the proportion of 21 to 20. The genital segment is fringed along the ventral part of the posterior margin with minute spinules. The 2nd abdominal segment is also armed with small spinules along the ventral part of the articulation with the furcal rami.

Distribution.—In the Pacific Ocean between lat. 5° N. and 3° S., long. 99°–115° W. (Giesbrecht), off New Guinea, New Pommerania, Pelee Islands and Luzon (M. Dahl), on the Australian Barrier Reefs (Farran), in the Aru Archipelago (Früchtl) and in the Malay Archipelago (A. Scott, as *gracilicaudatus*). In the Indian Ocean from Christmas Island (Farran), off Ceylon (M. Dahl, Thompson and A. Scott, as *gracilicaudatus*), Laccadive Sea (Thompson and A. Scott), Maldive and Laccadive Archipelagoes (Thompson and A. Scott, Wolfenden), the Arabian Sea (Cleve, Thompson and A. Scott, present records), the Gulf of Aden (A. Scott and off Madagascar (M. Dahl). It has been recorded as *gracilicaudatus* by Wolfenden from the tropical Atlantic.

Corycæus (*Onychocorycæus*) *catus* F. Dahl.

Corycæus catus, Farran, 1911, p. 290, pl. xii, figs. 1–3.
Corycæus (*Onychocorycæus*) *catus*, M. Dahl, 1912, p. 99, pl. xiii, figs. 17–24.
Corycæus obtusus, Giesbrecht, (part), p. 673, pl. li, figs. 12–14.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface, several males.

Descriptive Notes.—♂. The total length ranges from 0·80 to 0·867 mm., with a mean of 0·841 mm. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
343	99	55	96	24	219	72	90 = 1000.
			(35, 61)				

The cephalon and 1st thoracic segment are fused, but in stained specimens a darkly stained line, marking the line of fusion, can be seen crossing the dorsum.

The genital segment consists of a large oval region and a very short posterior cylindrical portion ; there is a small hook anteriorly on the ventral aspect. The genital aperture is armed with a delicate seta, on the inner side of which is a small triangular tooth.

In the following table I have given the various proportional lengths of different regions of the body, and for reference I have given the corresponding measurements as given by M. Dahl, recalculated as parts per 100 :

Dimensions.	From M. Dahl.	Present examples. (1).	Present examples. (2).
Anterior region to posterior	59 to 41 (35 : 24)	59 to 41	61 to 39
Cephalon—Th. 1 to total length	47·5 ,, 100 (28 : 59)	44·2 ,, 100	46 ,, 100
Genital segment :			
(*a*) Cylindrical region to total length	11 ,, 100 (4 : 36)	14 ,, 100	12 ,, 100
(*b*) Breadth to length of oval region	69 ,, 100 (22 : 32)	68 ,, 100	..
Breadth to length of anal segment	69 ,, 100 (9 : 13)	63 ,, 100	..
Anal segment to furcal ramus	86 ,, 100 (13 : 15)	86 ,, 100	86 to 100
Short furcal spine to long seta	19 ,, 100 (6 : 32)	23 ,, 100	26 ,, 100

The 1st antenna consists of the usual six segments having the proportional lengths of 20, 16. 16, 25, 12, 11.

The 2nd antenna more nearly approaches the condition figured by M. Dahl (pl. xiii, fig. 15) in *C. ovalis* Claus. Of the two basal spines the shorter, arising from the base of the 3rd segment, reaches to the spine on the anterior margin of the 3rd segment; the longer, arising from the 2nd segment, reaches well beyond the tip of the shorter. The shorter claw, arising from the proximal joint of the end region, is long and slender; the long distal claw reaches well beyond the base of the 2nd basal segment.

The swimming legs exhibit the usual characters, and there does not appear to be any distinguishing character in these appendages that will serve to discriminate between the various species.

Distribution.—According to M. Dahl this is an Indo-Pacific species. It has been recorded from the Australian Barrier Reefs (Farran), the Aru Archipelago (Früchtl), off Christmas Island (Farran) and from the Arabian Sea (present record).

Corycæus (*Onychocorycæus*) *pacificus* F. Dahl.

Corycæus (*Onychocorycæus*) *pacificus*, M. Dahl, 1912, p. 103, pl. xiv, figs. 1–10.
Corycæus obtusus, Farran, 1911, p. 291, pl. xii, figs. 4–6.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface.

Sta. 61 C, Northern area of Arabian Sea, surface.

Descriptive Notes.—♀. The total length ranges from 1·067 to 1·108 mm., with a mean of 1·073 mm. This is slightly larger than the measurement given by Farran for examples from Christmas Island, 1·05 to 1·1 mm., and also on the average slightly smaller than that given by M. Dahl of 1·09 mm.

The proportional lengths of the anterior and posterior regions of the body are as 66 to 34. The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.	
367	123	52	94	25	190	77	72	= 1000

In the following table I have given the proportional lengths in *ovalis* and *pacificus* of the cephalothorax and abdomen and of the three segments of the hind region of the body in parts per 100, and have recalculated the dimensions as given by M. Dahl :

	ovalis. (M. Dahl).	*pacificus.* Present examples.	*pacificus.* (M. Dahl).
Cephalothorax	67 (50)	66	63 (51)
Abdomen	33 (25)	34	37 (30)
,, 1	60 (36)	56	55 (38)
,, 2	20 (12)	23	22 (15)
Furca	20 (12)	21	23 (16)

It seems clear that the present examples are intermediate between the Pacific form, *pacificus*, and the Mediterranean form, *ovalis*, and the sole distinction between these forms appears to be the presence of a sharp spinous termination to the lateral process of the 4th thoracic segment in *ovalis* and its absence in *pacificus* ; I am therefore inclined to regard them as local races of the same species.

The cephalon and 1st thoracic segment are only partially fused, the line of demarcation between them being visible on the dorsal aspect, and in specimens that have been subjected to pressure the chitin splits along this line. The posterior processes of the 4th thoracic segment terminate in small blunt prominences, as figured by Farran (1911, pl. xii, fig. 5). The posterior border of the genital segment and the margin of the articulation with the furcal ramus on each side of the 2nd abdominal segment are armed with rows of small spinules on the ventral aspect.

In the same haul were a number of males that agree very closely with the description given by M. Dahl.

♂. The total length ranges from 0·98 to 1·03 mm. The proportional lengths of the anterior and posterior regions of the body are as 55 to 45, which agrees exactly with the measurements given by M. Dahl, viz. 39 to 32 (= 54·9 to 45·1). The proportional lengths of the various segments of the body are as follows :

Cephalon.	Th. 1.	Th. 2.	Th. 3–4.	Th. 5.	Abd. 1.	Abd. 2.	Furca.
322	86	40	95	21	236	91	109 = 1000

As in the female the cephalon and 1st thoracic segment are only partially fused, and in stained specimens the line of fusion is easily detectable as a deeply stained line running across the dorsum and down the side nearly to the lateral margin.

The 4th thoracic segment is produced backwards on each side in a wing that terminates in a short pointed spine. The 5th thoracic segment bears two small delicate setae.

The genital segment is five-ninths as broad as long, the actual proportions being 37 to 63. The genital aperture is guarded by a seta, on the inner side of which is a small triangular spinule. There is no spinous projection on the ventral aspect of the segment.

The 1st antenna resembles that of the female.

In the 2nd antenna the basal part appears to be composed of three segments, of which the proximal is small and incompletely annular in shape.

Distribution.—In the Pacific Ocean this has been recorded from New Pommerania, New Guinea and the Philippine Islands (M. Dahl), the China Sea (M. Dahl), the Australian

Barrier Reefs (Farran) and the Malay Archipelago (A. Scott, as *obtusus*). In the Indian Ocean it has been taken off Ceylon (Thompson and A. Scott as *obtusus*, M. Dahl), the Laccadive Sea and Maldive Archipelagoes (Thompson and A. Scott), Arabian Sea (Thompson and A. Scott, present record), the Gulf of Aden, Red Sea and Gulf of Suez (Thompson and A. Scott), off Zanzibar (M. Dahl).

Corycæus (*Onychocorycæus*) *pumilus* M. Dahl.

Corycæus (*Onychocorycæus*) *pumilus*, M. Dahl, 1912, p. 91, pl. xii, figs, 21–28.

Occurrence :

Sta. 56, South Arabian coast, surface, 1 female, ovigerous.

Sta. 61, Northern area of Arabian Sea, surface, 1 female.

Descriptive Notes.—♀. Total length from 0·65 mm. to 0·73 mm. The spine of the 3rd thoracic segment is sharply pointed and reaches to two-thirds the length of the genital segment. The proportional lengths of the segments of the abdomen and the furcal rami are as 60·3 : 22·4 : 17·3. The anal segment tapers posteriorly, so that the anterior diameter is half as long again as the posterior, the proportions being as 15 to 10 ; M. Dahl gives 10 to 8 (= 15 to 12) for her specimens. The furcal rami are slightly more than twice as long as broad and measure 10 by 4·5. Each furcal ramus bears a short spine less than half the length of the ramus itself, but the inner seta is somewhat longer than is stated by M. Dahl, who gives the proportions of the seta and the furcal ramus as 10 : 6 ; in the present specimens the proportional lengths are as 30 : 10.

The 1st antenna consists of the usual six segments, that have the proportional lengths of 19, 14, 18, 25, 13, 11.

The 2nd antenna closely resembles the figure given by M. Dahl (1912, pl. xii, fig. 25).

In the swimming feet the exopods (including the endspines) have the following relative lengths : 48 : 64 : 59 : 16. These figures agree extremely closely with the proportional lengths given by M. Dahl of the 1st three legs.

The figure which M. Dahl (1912, pl. xii, fig. 28) gives of the 2nd leg of the female appears to have been taken from an abnormal specimen, since there are only two marginal spines on the 3rd segment of the exopod. In the present specimen there are the usual three marginal spines.

Remarks.—I am very doubtful whether the distinction between *pumilus* M. Dahl and *medius* Gurney can be maintained. M. Dahl's specimens from the Bismark Archipelago possessed a total length of (♀) 0·65–0·68 mm. and (♂) 0·63–0·65 mm., while Gurney's examples from the Suez Canal measured (♀) 0·74–0·8 mm. and (♂) 0·66 mm. The present examples, which are both females, measure 0·65 and 0·73 mm. respectively, and are thus intermediate between the two forms. It is now well known that the size of a species may vary quite considerably in accordance with the degree of salinity of the water in which it is living. We should thus expect to find that examples of the same species were considerably larger in the Suez Canal, where the salinity may be as high as 35·5 at Port Said, 52·2 in the Great Bitter Lake and 43·8 in the Gulf of Suez,* whereas in the Bismark Archipelago the salinity is approximately 34·5 or less.†

* Munro Fox, 1926, ' Zoological Results of the Cambridge Expedition to the Suez Canal,' 1924, Pt. I, p. 30.

† Gerhard Schott, 1935, ' Geographie des Indischen und Stillen Ozeans,' pl. xxvii.

In the following Table I have given the proportional lengths and dimensions of the various parts of the body in the two "species" and in the present specimens :

Dimension.	*pumilus* M. Dahl.	Present examples.	*medius* Gurney.
♀.			
Total length	0·65–0·68 mm.	0·65–0·73 mm.	0·74–0·8 mm.
Proportions of thorax to abdomen	70 : 30 (35 : 15)	67 : 33	65 : 35
1st th. segment to whole body	58 : 100 (29 : 50)	52 : 100	" Nearly half."
Breadth to length of segment th. 1	Three-fourths	..	Three-fourths.
Spine of th. 3	Pointed and over-reaches two-thirds of genital segment	Sharply pointed and reaches to two-thirds of genital segment	Very sharp and reaches beyond middle of genital segment
Proportional lengths of abdominal segments	57 : 27 : 17 60 : 24 : 16 (20 or 22 : 9 : 6)	60·3 : 22·4 : 17·3	59·2 : 22·4 : 18·4
Breadth to length of furcal ramus	50 : 100 (3 : 6)	45 : 100	39 : 100 (7 : 18)
Long furcal seta to furcal length	100 : 60 (10 : 6)	100 : 33	100 : 24 (37 : 9)
♂.			
Total length	0·63–0·65 mm.	..	0·66 mm.
Proportions of thorax to abdomen	60 : 40	..	61 : 39
Proportional lengths of abdominal segments	51 : 24·5 : 24·5 (24 : 11·5 : 11·5)	..	50·8 : 24·6 : 24·6 (31 : 15 : 15)

Farran (1936, p. 138) remarks that the examples of what he takes to be *pusilus* M. Dahl from Christmas Island, while differing from the original description in some respects, comes nearer to it than to *medius* Gurney, except in the length of the long furcal seta, which was more than four times the length of the furcal ramus, thus agreeing with *medius*.

Distribution.—*C. pumilus* M. Dahl has now been recorded from the Bismark Archipelago (M. Dahl), the Australian Barrier Reefs (Farran), the Indian Ocean (M. Dahl) and the Arabian Sea (present record). If I am right in thinking that *C. medius* Gurney is a synonym, the species extends to the Red Sea and Suez Canal.

Sub-genus *Corycella* Farran.

Corycæus (*Corycella*) *gibbulus* Giesbrecht.

Corycæus gibbulus, Giesbrecht, 1892, p. 675, pl. li, figs. 22–23 ; Cleve, 1901, p. 41, pl. iv, figs. 3–10.
Corycæus (*Corycella*) *gibbulus*, M. Dahl, 1912, p. 115, pl. xv, figs. 1–4, 9, 10, 25, 35, 36.
Corycæus pellucidus, Wolfenden, 1906, p. 1027, pl. xcix, figs. 4–11.

Occurrence :

Sta. 61 A, Northern area of Arabian Sea, surface.

Sta. 61 C, Northern area of Arabian Sea, surface, numerous specimens of both sexes.

Sta. 136, Maldive area, surface, 5 females.

Descriptive Notes.—This species was by far the commonest among the Corycæidæ, and was especially numerous in the day haul at Sta. 61. ♀. Total length ranged from

0·85 to 1·0 mm., with a mean of 0·925 mm. ♂. Total length ranged from 0·817 to 0·950, with a mean of 0·882 mm.

REMARKS.—A number of specimens, especially the females, are infected with a parasite that appears to be identical with *Blastodinium mangini* Chatton (Chatton, 1920).

DISTRIBUTION.—M. Dahl states that this species appears to be confined to the Indo-Pacific region. It has been recorded from the Pacific Ocean in lat. 3°–15° N., long. 99°–138° W. (Giesbrecht) and from the Australian Barrier Reefs (Farran). In the Indian Ocean it has been taken off Christmas Island (Farran), in the Nicobar Islands (Sewell), the Bay of Bengal (Thompson), the Ceylon Pearl Banks (Thompson and A. Scott), the Maldive and Laccadive Archipelagoes (Wolfenden, as *pellucidus*), the equatorial region of the Indian Ocean (Thompson), the Arabian Sea, Gulf of Aden and Red Sea (present record, Cleve, Thompson and A. Scott), the Gulf of Suez (Thompson and A. Scott), and off the south-east coast of Africa (Wolfenden, as *pellucidus*). Wolfenden (1911, p. 359) has, however, also recorded *pellucidus* from several of the " Gauss " stations in the tropical Atlantic region.

HARPACTICOIDA.

Family ECTINOSOMIDÆ.

Genus *Ectinosoma* Boeck.

Ectinosoma melaniceps Boeck.

Ectinosoma melaniceps, Sewell, 1940, p. 139.

OCCURRENCE :

Sta. 61, Northern area of Arabian Sea, surface.

Nankauri Harbour, Nicobar Islands, surface.

DISTRIBUTION.—This species appears to have a wide distribution throughout the three great oceans, extending into both the Arctic and Antarctic regions.

Genus *Microsetella* Brady and Robertson.

Microsetella norvegica (Boeck).

Microsetella norvegica, Sewell, 1940, p. 140.

OCCURRENCE.—Sta. 61 C, Northern area of Arabian Sea, surface, a few examples.

DISTRIBUTION.—As I have pointed out in a previous paper (1940), this species occurs in all three great oceans, and has a range extending from lat. 66° S. in the Antarctic to Franz-Josef Land in the Arctic Ocean.

Microsetella rosea Dana.

Microsetella rosea, Giesbrecht, 1892, p. 550, pl. xliv, figs. 32, 35, 38, 41, 43, 48, 49.

OCCURRENCE.—Sta. 61 C, Northern area of Arabian Sea, surface, a few examples.

DISTRIBUTION.—This species has a wide distribution in all three great oceans. It has been recorded from the San Diego region of the Pacific coast of America (Esterly), between lat. 0°–11° N., long. 108°–124° W. (Giesbrecht), the Sulu Sea (Dana), off New Zealand

(Farran), in Fortescue Straits between Basilisk and Moresby Islands (A. Scott), in the Aru Archipelago (Früchtl) and in the Malay Archipelago (A. Scott). In the Indian Ocean it occurs off the Madras coast of India (Menon), on the Ceylon Pearl Banks, the Laccadive Sea and the Maldive and Laccadive Archipelagoes (Thompson and A. Scott), the Arabian Sea (Cleve, Thompson and A. Scott, present record), the Gulf of Aden (Thompson and A. Scott), the Red Sea (Cleve, Thompson, Thompson and A. Scott), the Gulf of Suez (Thompson, Thompson and A. Scott) and off the east coast of Africa in the Mozambique channel (Thompson). In the Atlantic Ocean it has been recorded from the South Atlantic as far as lat. 50° S. (Farran), in the temperate South Atlantic in lat. 26° 25′ S., long. 42° W. (T. Scott), the tropical Atlantic (Farran), the north temperate Atlantic (Rose, T. Scott, van Breemen), in the Woods Hole region of the east coast of America (Fish, Wilson), round the British Isles (Brady) and in the Mediterranean Sea (Giesbrecht, Cleve, Thompson and A. Scott, Pesta, Rose).

Family Tachidiidæ.

Genus *Euterpina* Norman.

Euterpina acutifrons (Dana).

Euterpina acutifrons, Sewell, 1940, p. 141.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, a few examples.

Distribution.—Widely distributed throughout the three great oceans.

Family Macrosetellidæ.

Genus *Macrosetella* A. Scott.

Macrosetella gracilis (Dana).

Macrosetella gracilis, Sewell, 1940, p. 141.

Occurrence :

Sta. 56, South coast of Arabia, surface, 11 specimens.

Sta. 61 C, Northern area of Arabian Sea, surface, several specimens.

Nankauri Harbour and Expedition Harbour, Nicobar Islands, surface.

Distribution.—Widely distributed throughout all three great oceans. It has also been recorded from Kerguelen Island and the Antarctic (Brady).

Macrosetella oculata (Sars).

Setella oculata, Sars, 1916, p. 13, pl. vii.
Miracia gracilis, Mrazek, 1894, p. 1, pl. xiv, figs. 4–17.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, 2 specimens.

Distribution.—This species has now been recorded from the southern Pacific Ocean (Dana), the southern part of the Indian Ocean in lat. 24° 15′ S., long 63° 30′ E., the Arabian Sea (present record), the North Atlantic (Sars) and the Woods Hole region of the east coast of North America (Wilson).

Genus *Miracia* Dana.

Miracia efferata Dana.

Miracia efferata, Sewell, 1940, p. 141.

Occurrence :

Sta. 61, Northern area of Arabian Sea, surface, 1 specimen.

"Investigator" Sta. 614, Nankauri Harbour, Nicobar Islands.

Distribution.—This species appears to be widely distributed throughout the three great oceans. It has been recorded from the South Pacific (Brady), 140 miles N.W. of New Zealand (Farran), in the south-east part of the Indian Ocean (Mrazek), in the Nicobar Islands (Sewell), the Bay of Bengal (Thompson, Mrazek), the Laccadive Sea (Mrazek, Thompson and A. Scott), the Maldive and Laccadive Archipelagoes (Thompson and A. Scott, Wolfenden), the southern region of the Arabian Sea (Thompson), the northern region of the Arabian Sea (A. Scott, present record), off the east coast of South Africa (Mrazek, Thompson), the Gulf of Guinea (T. Scott, Lubbock), the tropical Atlantic (Dana, Mrazek, Farran), the temperate region of the North Atlantic (Giesbrecht, Mrazek, Farran) and the Woods Hole Region of the east coast of North America (Wilson).

Family Clytemnestridæ.

Genus *Clytemnestra* Dana.

Clytemnestra rostrata (Brady).

Goniopsyllus rostratus, Brady, 1883, p. 107, pl. xlii, figs. 9–16.
Clytemnestra rostrata, Giesbrecht, 1892, p. 566, pl. xlv, figs. 19, 20, 22, 25, 26, 31, 33.

Occurrence.—Sta. 61 C, Northern area of Arabian Sea, surface, a few specimens.

Distribution.—The San Diego region of the coast of California (Esterly), the eastern tropical area of the Pacific Ocean (Giesbrecht), the Malay Archipelago (A. Scott), the Ceylon Pearl Banks, the Arabian Sea, the Gulf of Aden and the Red Sea (Thompson and A. Scott), the South Atlantic Ocean (Brady), the Gulf of Guinea (T. Scott), the North Atlantic Ocean (van Breemen), the Woods Hole region of the east coast of North America (Wheeler, Wilson) and the Mediterranean Sea (Giesbrecht, Steuer, Früchtl, Pesta, Rose).

Clytemnestra scutellata Dana.

Clytemnestra scutella, Giesbrecht, 1892, p. 566, pl. xlv, figs. 16–18, 21, 23, 24, 27–30, 32, 34–38; Sewell, 1940, p. 142.

Occurrence :

Sta. 61, Northern area of Arabian Sea, surface.

The Nicobar Islands, surface.

Distribution.—This species appears to be widely distributed throughout all three great oceans.

Family Pontostratiotidæ.

Genus *Ægisthus* Giesbrecht.

Ægisthus aculeatus Giesbrecht.

Ægisthus aculeatus, Sewell, 1940, p. 142.

Occurrence.—" Investigator " Sta. 682, Laccadive Sea, lat. 10° 26′ N., long. 74° 32′ 30″ E., surface.

Distribution.—In all three great oceans.

Ægisthus mucronatus Giesbrecht.

Ægisthus mucronatus, Sweell, 1940, p. 142.

Occurrence.—" Investigator " Sta. 682, Laccadive Sea, lat. 10° 26′ N., long. 74° 32′ 30″ E., surface.

Distribution.—In all three great oceans.

APPENDIX.

A LIST OF SPECIES AND THE NUMBERS OF INDIVIDUALS CAPTURED AT DIFFERENT STATIONS.

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
42	0	*Sapphirina iris* Dana	2	1	—
43	83	*S. iris* Dana	31	6	—
45	38	*Calanoides patagoniensis* Brady	—	—	1
		Labidocera acuta (Dana)	—	1	—
56	0	*Nannocalanus minor* (Claus)	—	1	—
		Canthocalanus pauper (Giesbrecht)	3		—
		Schmackeria serricaudata (T. Scott)	Several		—
		Pseudodiaptomus salinus (Giesbrecht)	— —	1	—
		Temora discaudata Giesbrecht	—	5	—
		T. turbinata (Dana)	3	2	—
		Calanopia elliptica (Dana)	—	2	—
		Labidocera acuta (Dana)	3	57	—
		L. acutifrons (Dana)	2	1	—
		L. minuta Giesbrecht	1	12	—
		Oithona brevicornis Giesbrecht	—	—	—
		O. nana Giesbrecht	—	—	—
		Oncæa conifera Giesbrecht	—	—	—
		Sapphirina iris Dana		1	—
		Corycæus agilis Dana	10	23.	
		C. asiaticus F. Dahl	1	2	—
		C. lubbocki Giesbrecht	1	—	—
		C. pumilus M. Dahl	1	—	—
		Macrosetella gracilis (Dana)	11		—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
58	0	*Schmackeria serricaudata* (T. Scott)	Several		—
		Labidocera acuta (Dana)	11		—
		L. acutifrons (Dana)	—	1	—
61 A	0	*Nannocalanus minor* (Claus)	120		—
		Calocalanus pavo (Dana)	240		—
		Paracalanus denudatus Sewell	240		—
		Acrocalanus longicornis Giesbrecht	360		—
		A. monachus Giesbrecht	240		—
		Clausocalanus furcatus (Brady)	120		—
		Euchæta wolfendeni A. Scott	960		—
		Centropages gracilis (Dana)	1,200		—
		C. orsinii Giesbrecht	120		—
		Acartia amboinensis Carl	120		—
		Oncæa media Giesbrecht	6,482		—
		Corycæus agilis Dana	360		—
		C. crassiusculus Dana	12	3	—
		C. speciosus Dana	Several		—
		C. catus F. Dahl	—	Several	—
		C. pacificus F. Dahl	—	—	—
		Corycella gibbulus Giesbrecht		Numerous	
	500	*Euchirella bella* Giesbrecht	1	—	—
	1000	*Eucalanus elongatus* (Dana)	4		—
		Rhincalanus nasutus Giesbrecht	7		—
		Euchirella bella Giesbrecht	1	—	—
		Euchæta marina (Prestandrea)	18	—	—
		E. wolfendeni A. Scott	6		—
		Lucicutia challengeri Sewell	12		—
		Euaugaptilus latifrons Sars	—	—	1
		E. nodifrons Sars	12		—
		Centraugaptilus horridus (Farran)	2		—
		Pachyptilus eurygnathus Sars	1	—	—
		Pontella securifer Brady	3	—	—
		Sapphirina ovatolanceolata-gemma Dana	—	1	—
		Copilia mirabilis Dana, f. *typica*	—	3	—
		C. quadrata Dana	—	1	—
	1500	*Eucalanus elongatus* (Dana)	100		—
		E. mucronatus Giesbrecht	—	—	—
		E. pseudattenuatus sp. nov.	7		—
		Rhincalanus nasutus Giesbrecht	6		—
		Gætanus antarcticus Wolfenden	2	—	2
		G. curvicornis Sars	2	—	—
		Euchirella bella Giesbrecht	8	—	—
		E. maxima Wolfenden	1	—	1
		Pseudochirella notacantha Sars	—	—	1
		Pseudeuchæta brevicauda Sars	1	—	1
		Valdiviella oligarthra Steuer	1	—	—
		Euchæta marina (Prestandrea)	38	3	—
		E. murrayi sp. nov.	1	—	—
		E. wolfendeni A. Scott	14	—	—
		Paraeuchæta bisinuata Sars	1	—	—
		Lophothrix humilifrons Sars	1	—	—
		Metridia princeps Giesbrecht	4	—	2
		Lucicutia challengeri Sewell	11		—
		Heterostylites longicornis (Giesbrecht)	1	1	—
		Hemirhabdus truncatus (A. Scott)	—	—	1
		Haloptilus chierchiæ (Giesbrecht)	59		—
		Euaugaptilus angustus Sars	1	—	—
		E. digitatus Sars	1	—	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
61 A .	1500 .	*E. elongatus* Sars	1	—	—
(*cont.*)	(*cont.*)	*E. grandicornis* Sars	2	—	—
		E. laticeps Sars	3	—	1
		E. longimanus Sars	1	—	—
		E. magnus (Wolfenden)	—	—	3
		E. nodifrons Sars	22		—
		E. penicillatus Sars	1	—	—
		E. tenuispinus Sars	1	—	—
		Centraugaptilus horridus (Farran)	1	—	—
		Pachyptilus eurygnathus Sars	2	—	—
		P. lobatus	1	—	—
		Candacia pachydactyla (Dana)	1	—	—
		Pontella securifer Brady	1	—	—
		Copilia mediterranea (Claus)	—	6	—
		C. mirabilis Dana	—	5	—
	2000 .	*Undinula darwini* (Lubbock)	3	—	2
		Euchæta marina (Prestandrea)	1	2	—
		E. wolfendeni A. Scott	8	2	—
		Centropages gracilis (Dana)	1	1	—
		Haloptilus acutifrons (Giesbrecht)	1	—	—
		Euaugaptilus magnus (Wolfenden)	1	—	—
		Labidocera detruncata (Dana)	2	1	—
		Oncæa venusta Philippi	19	3	—
61 C .	0 .	*Nannocalanus minor* (Claus)	14,280		—
		Canthocalanus pauper (Giesbrecht)	360		—
		Undinula darwini (Lubbock)	3,120		—
		U. vulgaris (Dana)	240		—
		Eucalanus attenuatus (Dana)	19	7	—
		E. pileatus Giesbrecht	120		—
		E. pseudattenuatus sp. nov.	112	3	9
		E. subcrassus Giesbrecht	Several		
		E. subtenuis Giesbrecht	—	—	—
		Paracalanus aculeatus Giesbrecht	10,680		—
		P. denudatus Sewell	8,280		—
		P. parvus Giesbrecht	2,760		—
		Acrocalanus longicornis Giesbrecht	360		—
		A. monachus Giesbrecht	—	—	—
		Calocalanus pavo (Dana)	Many		
		C. plumulosus (Claus)	Several		
		Clausocalanus arcuicornis (Dana)	Numerous		
		C. farrani Sewell	360		—
		C. furcatus (Brady)	11,280		—
		Euchirella orientalis Sewell	—	2	—
		Euchæta consimilis Farran	3	—	—
		E. marina (Prestandrea)	1,205		—
		E. wolfendeni A. Scott	7,086		—
		Scolecithricella tenuiserrata (Giesbrecht)	1	—	—
		Centropages calaninus (Dana)	—	1	—
		C. gracilis (Dana)	Numerous		
		C. orsinii Giesbrecht	,,		
		Lucicutia flavicornis (Claus)	1	—	—
		Candacia æthiopica (Dana)	120		—
		C. curta (Dana)	120		—
		C. pachydactyla (Dana)	1	—	—
		Labidocera detruncata (Dana)	3,290		—
		Pontella securifer Brady	59	21	—
		Acartia amboinensis Carl	Several		
		A. erythræa Giesbrecht	—	—	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
61 C	0	*A. pietschmani* Pesta	1	—	—
(*cont.*)	(*cont.*)	*Oithona fallax* Farran	2	—	—
		O. plumifera Baird		Numerous	
		O. rigida Giesbrecht	1	—	—
		Oncœa clevei Früchtl		Several	
		O. conifera Giesbrecht	1	—	—
		O. media Giesbrecht		Several	
		O. venusta Philippi		Numerous	
		Sapphirina bicuspidata Giesbrecht	1	—	—
		S. nigromaculata Claus	5	3	—
		S. ovatolanceolata-gemma Dana	2	—	—
		S. sinuicauda Brady	1	1	—
		S. stellata Giesbrecht	1	—	—
		Copilia mirabilis Dana	120		—
		Corycæus agilis Dana	120		—
		C. crassiusculus Dana	8	—	—
		C. pacificus F. Dahl	—	—	—
		C. speciosus Dana		Several	
		Corycella gibbula Giesbrecht	1,720	1,560	—
		Ectinosoma melaniceps Boeck	—	—	—
		Macrosetella gracilis (Dana)	120		—
		M. oculata (Sars)	2	—	—
		Miracia efferata Dana	1	—	—
		Clytemnestra rostrata (Brady)		Few	
		C. scutellata Dana	—	—	—
	1000	*Eucalanus elongatus* (Dana)	33		—
		Rhincalanus nasutus Giesbrecht	2		—
		Euchirella bella Giesbrecht	14	1	4
		Euchæta marina (Prestandrea)	104	12	—
		E. murrayi sp. nov.	5	—	—
		E. wolfendeni A. Scott	63	8	—
		Labidocera detruncata (Dana)	11	11	—
		Copilia mediterranea (Claus)	—	6	—
		C. mirabilis Dana. f. *typica*	—	23	—
		C. quadrata Dana	—	8	—
		C. vitrea (Haeckel)	—	2	—
	1500	*Calanus finmarchicus* (Gunnerus)	—	1	
		Nannocalanus minor (Claus)	5	2	
		Eucalanus elongatus (Dana)	43		
		E. pseudattenuatus sp. nov.	15		
		Rhincalanus nasutus Giesbrecht	2		—
		Gætanus curvicornis Sars	1		—
		Euchirella bella Giesbrecht	3	—	—
		Euchæta marina (Prestandrea)	40	2	—
		E. murrayi sp. nov.	2	—	—
		E. wolfendeni A. Scott	9	—	—
		Amallothrix indica Sewell	1	—	—
		Metridia princeps Giesbrecht	—	1	—
		Mesorhabdus angustus Sars	1	—	—
		Euaugaptilus angustus Sars	1	—	—
		E. grandicornis Sars	5	—	2
		E. latifrons Sars	1	—	—
		E. magnus (Wolfenden)	4	—	2
		E. nodifrons Sars	17		—
		E. oblongus Sars	1	—	—
		Centraugaptilus horridus Farran	1	—	—
		Haloptilus chierchiæ (Giesbrecht)	26	1	—
		Pachyptilus eurygnathus Sars	6	—	—

Sta.	Approximate depth of net. (m.)	Species.	♀.		♂.	juv.
61 C (*cont*).	1500 (*cont*).	*Heteroptilus* sp.	—		1	—
		Candacia varicans Giesbrecht	—		1	
		Labidocera detruncata (Dana)	—		2	—
		Pontellopsis regalis (Dana)	—		1	—
		Copilia mediterranea (Claus)	—		8	—
		C. mirabilis, f. *typica* Dana	—		38	—
		C. mirabilis, f. *platonyx* Lehnhofer	—		2	—
		C. quadrata Dana	—		2	—
	2000	*Nannocalanus minor* (Claus)	9		1	1
		Eucalanus elongatus (Dana)	1		—	—
71	106	*E. elongatus* (Dana)	3		—	—
76	200	*E. elongatus* (Dana)	41		10	—
		E. crassus Giesbrecht		16		—
		Rhincalanus nasutus Giesbrecht		44		—
		Euchæta marina (Prestandrea)	4		—	—
		E. wolfendeni A. Scott	11		—	—
		Candacia curta (Dana)	4		—	—
		Labidocera acuta (Dana)	6		2	—
		Copilia mediterranea (Claus)	—		2	—
		C. mirabilis Dana	—		41	—
	600	*Calanoides patagoniensis* Brady	—		—	3
		Eucalanus attenuatus (Dana)		50		—
		E. crassus Giesbrecht	9		—	—
		E. elongatus (Dana)	2,061		29	—
		Rhincalanus nasutus Giesbrecht	803		—	—
		Euchirella maxima Wolfenden	1		1	1
		Euchæta marina (Prestandrea)	1		—	—
		E. murrayi sp. nov.	1		—	—
		E. wolfendeni A. Scott	5		—	—
		Mesorhabdus angustus Sars	1		1	1
		Disseta palumboi Giesbrecht	1		—	—
		Haloptilus acutifrons (Giesbrecht)	1		—	—
		Labidocera acuta (Dana)	1		—	—
		Copilia mirabilis (Dana)	—		14	—
	1500	*Calanoides patagoniensis* Brady	—		—	2
		Eucalanus elongatus (Dana)		351		—
		E. crassus Giesbrecht	7		1	—
		E. mucronatus Giesbrecht	—		—	—
		Euchirella bella Giesbrecht	2		—	—
		Euchæta murrayi sp. nov.	1		—	—
		E. wolfendeni A. Scott	4		—	—
		Onchocalanus affinis With	—		—	1
		Scaphocalanus magnus (T. Scott)	1		—	—
		Metridia princeps Giesbrecht	1		—	—
		Pleuromamma indica Wolfenden	2		—	—
		Lucicutia challengeri Sewell	61		12	12
		Euaugaptilus longimanus Sars	—		—	1
		E. nodifrons Sars	2		—	—
		Centraugaptilus horridus Farran	3		—	—
		Haloptilus chierchiæ (Giesbrecht)	50		2	—
		Phyllopus impar Farran	1		—	—
		Pachyptilus eurygnathus Sars	1		—	—
		Candacia curta (Dana)	2		—	—
		Pontella securifer Brady	1		—	—
	2500	*Bathycalanus bradyi* (Wolfenden)	1		—	—
		Gætanus antarcticus Wolfenden	1		—	—
95	983–430	*Gaussia princeps* (T. Scott)	1		2	—

St.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
96	14	*Eucalanus crassus* Giesbrecht	2	—	—
		E. mucronatus Giesbrecht	—	—	—
		E. subcrassus Giesbrecht	2	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	867		—
		R. nasutus Giesbrecht	13		—
		Paracalanus aculeatus Giesbrecht	2	1	1
		P. denudatus Sewell	3	—	—
		Acrocalanus longicornis Giesbrecht	2	—	—
		Calocalanus pavo (Dana)	2	—	—
		Euchæta marina (Prestandrea)	6	1	—
		E. wolfendeni A. Scott	11	1	—
		Oithona plumifera Baird	7	1	—
		Sapphirina angusta Dana	1	2	—
		S. nigromaculata Claus	1	2	—
		S. ovatolanceolata-gemma Dana	2	—	—
		Copilia lata Giesbrecht	10	—	—
		C. mirabilis Dana	19	4	—
	645–400	*Megacalanus princeps* Wolfenden	—	—	1
		Eucalanus attenuatus (Dana)	182	119	—
		E. elongatus (Dana)	254	4	—
		E. mucronatus Giesbrecht	—	—	—
		E. pseudattenuatus sp. nov.	4	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	71		—
		R. nasutus Giesbrecht	942		—
		Gætanus kruppi Giesbrecht	4	—	5
		G. miles Giesbrecht	6	—	1
		G. pileatus Farran	3	—	1
		Euchirella bella Giesbrecht	1	1	—
		E. galeata Giesbrecht	22	—	33
		E. orientalis Sewell	40	2	5
		Chirundina indica Sewell	12	2	5
		C. streetsi Giesbrecht	—	—	4
		Pseudochirella magna (Wolfenden)	1	—	—
		Undeuchæta bispinosa Esterly	1	1	3
		Euchæta marina (Prestandrea)	78	3	—
		E. tenuis Esterly	20	—	—
		E. wolfendeni A. Scott	3	—	—
		Paraeuchæta investigatoris Sewell	16	4	—
		P. tonsa Giesbrecht	—	1	—
		P. weberi A. Scott	1	—	—
		Onchocalanus trigoniceps Sars	—	—	1
		Scottocalanus dauglishi Sewell	59	34	—
		Scaphocalanus magnus (T. Scott)	5	—	1
		Lophothrix frontalis Giesbrecht	4	—	3
		Amallothrix indica Sewell	5	—	—
		Centropages gracilis (Dana)	1	—	—
		Metridia princeps Giesbrecht	—	1	—
		Pleuromamma xiphias (Giesbrecht)	321	155	—
		Lucicutia challengeri Sewell	2	—	1
		Heterorhabdus spinifrons (Claus)	—	2	—
		H. abyssalis (Giesbrecht)	4	1	—
		Disseta palumboi Giesbrecht	1	—	1
		Euaugaptilus magnus (Wolfenden)	2	—	—
		E. nodifrons Sars	2	1	—
		Haloptilus validus Sars	1	—	—
		Arietellus plumifer Sars	1	—	2
		A. simplex Sars	1	—	—
		Sapphirina angusta Dana	—	2	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
96 (*cont.*)	645–400 (*cont.*)	*S. opalina-darwini* Haeckel	22	13	—
		S. ovatolanceolata-gemma Dana	—	1	—
		Copilia lata Giesbrecht	2	1	—
		C. mirabilis Dana	—	8	—
98	2800	*Megacalanus princeps* Wolfenden	1	—	—
		M. princeps var. *inermis* nov.	1	—	—
120	2926	*Bradycalanus gigas* sp. nov.	1	—	—
131 A	600	*Paraeuchæta sarsi* Farran	1	—	—
131 D	500	*Neocalanus gracilis* (Dana)	9	—	1
		N. robustior (Giesbrecht)	2	—	3
		Megacalanus princeps Wolfenden	1	—	—
		Eucalanus attenuatus (Dana)	6	—	—
		E. elongatus (Dana)	3	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	26		—
		Gœtanus pileatus Farran	—	—	1
		Euchirella truncata Esterly	1	1 ?	1
		Euchœta marina (Prestandrea)	76	2	—
		E. media Giesbrecht	2	—	—
		E. tenuis Esterly	1	—	—
		Paraeuchœta scotti (Farran)	1	—	—
		Scottocalanus persecans (Giesbrecht)	1	1	—
		S. securifrons (T. Scott)	2	2	—
		Pleuromamma abdominalis (Lubbock)	2	4	12
		P. quadrungulata (F. Dahl)	6		—
		P. xiphias (Giesbrecht)	3	2	—
		Heterostylites longicornis (Giesbrecht)	1	—	—
		Haloptilus mucronatus (Claus)	1	—	—
		H. ornatus (Giesbrecht)	2	—	—
		H. oxycephalus (Giesbrecht)	1	—	—
		Arietellus giesbrechti Sars	1	—	—
		Candacia æthiopica (Dana)	1	—	—
		C. bipinnata Giesbrecht	4	—	—
		C. curta (Dana)	1	1	—
		C. longimana Claus	—	3	—
		C. pachydactyla (Dana)	2	1	—
		C. simplex Giesbrecht	1	—	—
		Sapphirina angusta Dana	18		—
		S. nigromaculata Claus	1	—	—
		S. opalina-darwini Haeckel	—	5	—
		S. ovatolanceolata-gemma Dana	6		—
		Copilia hendorfi Dahl	—	1	—
		C. mirabilis, f. *typica* Dana	1	81	—
		C. mirabilis, f. *platonyx* Lehnhofer	—	1	—
		C. vitrea (Haeckel)	—	8	—
	850	*Undinula darwini* (Lubbock)	1	—	—
	1500	*Neocalanus robustior* (Giesbrecht)	6	—	—
		Megacalanus princeps Wolfenden	2	—	5
		Bathycalanus sp. (? *bradyi* Wolfenden)	—	—	1
		Eucalanus mucronatus Giesbrecht	—	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus		1	—
		R. nasutus Giesbrecht	25		—
		Gœtanus brevicornis Esterly	1	—	—
		G. kruppi Giesbrecht	1	1	—
		G. pileatus Farran	—	—	1
		Euchirella bella Giesbrecht	1	—	—
		E. galeata Giesbrecht	1	—	—
		E. pulchra (Lubbock)	2	—	—
		E. venusta Giesbrecht	2	—	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
131 D	1500	*Chirundina indica* Sewell	2	1	—
(*cont.*)	(*cont.*)	*C. streetsi* Giesbrecht	1	—	—
		Pseudochirella obtusa Sars	1	—	—
		Undeuchæta bispinosa Esterly	8	—	—
		U. major Giesbrecht	1	—	—
		Euchæta marina (Prestandrea)	36	7	—
		E. media Giesbrecht	1	—	—
		E. tenuis Esterly	4	—	—
		Paraeuchæta malayensis Sewell	1	—	—
		P. sarsi Farran	1	—	—
		P. tonsa Giesbrecht	—	1	—
		P. weberi A. Scott	4	—	—
		P. withi sp. nov.	—	1	—
		Scaphocalanus magnus (T. Scott)	2	—	—
		Lophothrix frontalis Giesbrecht	2	—	—
		Metridia princeps Giesbrecht	5	—	1
		Pleuromamma abdominalis (Lubbock)	4	—	1
		P. quadrungulata (F. Dahl)	7	—	—
		P. xiphias (Giesbrecht)	17	20	—
		Lucicutia bicornuta Wolfenden	1	1	—
		Heterorhabdus abyssalis (Giesbrecht)	1	—	—
		Hemirhabdus grimaldii (Richard)	—	1	—
		Disseta palumboi Giesbrecht	3	5	—
		Euaugaptilus bullifer (Giesbrecht)	1	—	—
		E. nodifrons Sars	1	—	—
		Candacia æthiopica (Dana)	1	—	—
		C. bipinnata Giesbrecht	2	—	—
		C. pachydactyla (Dana)	2	1	—
		C. varicans Giesbrecht	1	—	
		Sapphirina angusta Dana	—	15	—
		S. opalina-darwini Haeckel	—	4	—
		S. ovatolanceolata-gemma Dana	—	3	—
		Copilia mirabilis Dana	—	43	—
		C. vitrea (Haeckel)	—	2	—
		Corycæus longistylis Dana	1	—	—
	2500	*Megacalanus princeps* Wolfenden	1	—	—
		Paraeuchæta sarsi Farran	1	—	—
136	0	*Undinula vulgaris* (Dana)	—	—	33
		Acrocalanus gracilis Giesbrecht	23	—	6
		Candacia pachydactyla (Dana)	—	1	—
		Corycella gibbula Giesbrecht	5	—	—
145 C	50–0	*Euchirella galeata* Giesbrecht	—	—	1
	(vertical)	*Undeuchæta bispinosa* Esterly	—	—	2
		Euchæta marina (Prestandrea)	7	1	—
		E. wolfendeni A. Scott	1	—	—
		Scottocalanus dauglishi Sewell	1	—	—
		Candacia æthiopica (Dana)	1	—	—
		C. bispinosa (Claus)	1	—	—
		C. pachydactyla (Dana)	3	—	—
		Copilia mirabilis Dana	—	2	—
	100–0	*Rhincalanus cornutus*, f. *typica* Schmaus	3		
	300–0	*Eucalanus elongatus* (Dana)	8	1	
		Rhincalanus cornutus, *f. typicus* Schmaus.	8		—
		Gætanus miles Giesbrecht	2	—	—
		Euchæta marina (Prestandrea)	7	—	—
		Pleuromamma quadrungulata (F. Dahl)	4	—	—
		P. xiphias (Giesbrecht)	1	1	—
		Candacia pachydactyla (Dana)	2	1	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
145 C .	300–0 .	*Copilia mediterranea* (Claus) . .	—	3	—
(*cont.*)	(*cont.*)	*C. mirabilis* f. *typica* Dana . . .	1	6	—
		C. mirabilis, f. *platonyx* Lehnhofer .	—	1	—
	500–0 .	*Eucalanus elongatus* (Dana) . . .	—	2	—
		E. mucronatus Giesbrecht . . .	—	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	2		—
		R. nasutus Giesbrecht . . .	1		—
		Euchirella bella Giesbrecht . . .	1	—	—
		E. orientalis Sewell	1	—	—
		Chirundina indica Sewell . . .	3	—	—
		Pseudochirella magna (Wolfenden) .	—	—	1
		Undeuchæta bispinosa Esterly . .	10	—	—
		Euchæta marina (Prestandrea) . .	4	1	—
		E. tenuis Esterly	—	1	—
		Scottocalanus dauglishi Sewell . .	4	—	—
		Pleuromamma xiphias (Giesbrecht) .	7	5	—
		Lucicutia magna Wolfenden . .	1	—	—
		Haloptilus chierchiæ (Giesbrecht) . .	1	—	—
		Copilia mirabilis Dana . . .	—	1	—
145 D .	50–0 .	*Rhincalanus cornutus*, f. *typicus* . .	1		—
		Euchæta marina (Prestandrea) . .	3	—	—
		E. wolfendeni A. Scott . . .	1	—	—
		Candacia æthiopica (Dana) . . .	1	—	—
		Oncæa venusta Philippi . . .	1	13	—
		Sapphirina opalina-darwini Haeckel .	1	—	—
		Copilia mirabilis, f. *platyonyx* Lehnhofer	—	1	—
	100–0 .	*Rhincalanus cornutus*, f. *typicus* Schmaus	12		—
		Euchirella bella Giesbrecht . . .	2	—	—
		Euchæta marina (Prestandrea) . .	3	—	—
		Pleuromamma quadrungulata (F. Dahl)	2	—	—
		Candacia pachydactyla (Dana) . .	—	1	—
		Copilia mirabilis, f. *typica* Dana . .	—	13	—
		C. mirabilis, f. *platyonyx* Lehnhofer .	—	4	—
	300–0 .	*Eucalanus elongatus* (Dana) . . .	1	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	4		—
		Gætanus latifrons Sars . . .	—	—	1
		Chirundina indica Sewell . . .	3	—	1
		C. streetsi Giesbrecht	—	—	1
		Pseudochirella magna (Wolfenden) .	—	—	1
		Undeuchæta bispinosa Esterly . .	3	—	2
		Euchæta marina (Prestandrea) . .	1	1	—
		Scottocalanus dauglishi Sewell . .	3	3	—
		S. helenæ (Lubbock)	—	1	—
		Pleuromamma quadrungulata (F. Dahl) .	1	—	—
		P. xiphias (Giesbrecht) . . .	—	3	—
		Copilia mirabilis, f. *platyonyx* Lehnhofer	—	1	—
	500–0 .	*Eucalanus elongatus* (Dana) . . .	2	—	—
		E. pseudattenuatus sp. nov. . . .	1	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	10		—
		Euchirella bella Giesbrecht . . .	1	—	2
		E. gapeata Giesbrecht . . .	2	—	—
		Chirundina indica Sewell . . .	2	—	—
		C. streetsi Giesbrecht	—	—	1
		Undeuchæta bispinosa Esterly . .	8	—	1
		Scottocalanus dauglishi Sewell . .	9	1	—
		Lophothrix frontalis Giesbrecht . .	—	—	1
		Pleuromamma abdominalis (Lubbock) .	1	—	—
		P. quadrungulata (F. Dahl) . . .	1	1	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
145 D (*cont.*)	. 500–0 (*cont.*) .	*P. xiphias* (Giesbrecht)	4	4	—
		Heterorhabdus abyssalis (Giesbrecht) .	—	1	—
		Augaptilus longicaudatus (Claus) . .	1	—	—
		Candacia pachydactyla (Dana) . .	1	—	—
		Pontellopsis regalis (Dana) . . .	1	—	—
		Copilia mediterranea (Claus) . .	—	2	—
		C. mirabilis, f. *typica* Dana . .	1	5	—
		C. mirabilis, f. *platyonyx* Lehnhofer .	—	2	—
172 .	200 .	*Undinula vulgaris* (Dana) . . .	—	1	1
		Eucalanus attenuatus (Dana) . .	2	—	—
		E. elongatus (Dana)	260	3	—
		Rhincalanus cornutus, f. *typicus* Schmaus	57		—
		R. nasutus Giesbrecht	667		—
		Euchirella bella Giesbrecht . . .	1	—	—
		E. orientalis Sewell	1	—	—
		E. pulchra (Lubbock)	—	3	—
		Euchaeta tenuis Esterly . . .	5	2	—
		Pleuromamma abdominalis (Lubbock) .	—	—	6
		P. xiphias (Giesbrecht) . . .	4	—	—
		Heterorhabdus spinifrons (Claus) . .	—	1	—
		Euaugaptilus nodifrons Sars . .	2	—	—
		Arietellus giesbrechti Sars . . .	2	—	—
		Candacia curta (Dana) . . .	—	1	—
		C. pachydactyla (Dana) . . .	—	1	—
		Pontella securifer Brady . . .	1	—	—
		Pontellopsis perspicax (Dana) . .	1	—	—
	400 .	*Eucalanus attenuatus* (Dana) . .	217	33	—
		E. elongatus (Dana)	302	—	—
		E. pseudattenuatus sp. nov. . . .	5		—
		E. mucronatus Giesbrecht . . .	—	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus.	55		—
		R. nasutus Giesbrecht . . .	744		—
		Gaetanus pileatus Farran . . .	2	—	1
		Euchirella galeata Giesbrecht . .	62	—	22
		E. orientalis Sewell	82	23	—
		E. truncata Esterly	2	—	—
		Chirundina indica Sewell . . .	23	—	—
		Undeuchaeta bispinosa Esterly . .	19	1	—
		Euchaeta tenuis Esterly . . .	56	15	—
		E. media Giesbrecht	4	—	—
		Paraeuchaeta weberi A. Scott . .	2	—	—
		P. investigatoris Sewell . . .	2	9	—
		Scottocalanus dauglishi Sewell . .	76	57	—
		S. securifrons (T. Scott) . . .	18	11	—
		Scaphocalanus magnus (T. Scott) . .	1	—	—
		Metridia princeps Giesbrecht . .	—	1	—
		Pleuromamma abdominalis (Lubbock) .	21		—
		P. indica Wolfenden	1		—
		P. quadrungulata (F. Dahl) . . .	7	—	—
		P. xiphias (Giesbrecht) . . .	97	125	—
		Heterorhabdus abyssalis (Giesbrecht) .	2	—	—
		H. spinifrons (Claus)	1	—	—
		Arietellus giesbrechti Sars . . .	—	1	—
		Candacia pachydactyla (Dana) . .	2	1	—
		Pontella fera Dana	—	1	—
		Copilia mirabilis Dana . . .	1	2	—
	850 .	*Calanoides patagoniensis* Brady . .	—	—	—
		Undinula vulgaris (Dana) . . .	1	—	—
		Megacalanus princeps Wolfenden . .	—	—	2

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
172	850	*Eucalanus attenuatus* (Dana)	329	144	—
(*cont.*)	(*cont.*)	*E. crassus* Giesbrecht	1	—	—
		E. elongatus (Dana)	556	11	—
		E. monachus Giesbrecht	5	—	13
		E. mucronatus Giesbrecht	—	—	—
		Rhincalanus cornutus, f. *typicus* Schmaus	129		—
		R. nasutus Giesbrecht	1,249		—
		Gætanus miles Giesbrecht	2	—	—
		G. minor Farran	1	—	—
		G. brevicornis Esterly	1	—	—
		Gkruppi Giesbrecht	63	1	3
		G. pileatus Farran	—	—	1
		Euchirella galeata Giesbrecht	38	—	5
		E. orientalis Sewell	61	16	—
		E. pulchra (Lubbock)	—	4	—
		Chirundina indica Sewell	63	—	—
		C. streetsi Giesbrecht	—	—	9
		Undeuchæta bispinosa Esterly	56	1	—
		Euchæta marina (Prestandrea)	1	—	—
		E. media Giesbrecht	1	—	—
		E. spinosa Giesbrecht	1	—	—
		E. tenuis Esterly	74	5	—
		Paraeuchæta investigatoris Sewell	36	9	—
		P. malayensis Sewell	4	1	—
		P. sarsi Farran	1	1	—
		P. spinifera Esterly	—	1	—
		P. tonsa Giesbrecht	—	1	—
		P. weberi A. Scott	18	—	—
		Xanthocalanus greeni Farran	—	1	—
		Onchocalanus affinis With	1	—	1
		O. trigoniceps Sars	1	—	6
		Scottocalanus securifrons (T. Scott)	1	—	—
		Scaphocalanus magnus (T. Scott)	10	—	—
		Lophothrix frontalis Giesbrecht	10	1	2
		L. quadrispinosa Wolfenden	4	—	—
		Amallothrix arcuata Sars	2	1	—
		A. emarginata (Farran)	1	—	—
		A. gracilis Sars	1	—	—
		Metridia princeps Giesbrecht	3	1	1
		Pleuromamma abdominalis (Lubbock)	17		—
		P. indica Wolfenden	—	1	—
		P. xiphias (Giesbrecht)	139	108	—
		Gaussia princeps (T. Scott)	—	1	—
		Lucicutia challengeri Sewell	32		—
		Heterorhabdus abyssalis (Giesbrecht)	2	—	—
		H. spinifrons (Claus)	—	1	—
		Hemirhabdus truncatus (A. Scott)	1	—	—
		Disseta palumboi Giesbrecht	6	5	7
		Euaugaptilus elongatus Sars	1	—	
		E. facilis (Farran)	1	—	—
		E. indicus Sewell	—	—	1
		E. laticeps Sars	—	—	1
		E. latifrons Sars	1	—	—
		E. longicirrhus Sars ?	—	—	1
		E. longimanus Sars	—	—	1
		E. magnus (Wolfenden)	—	—	3
		E. nodifrons Sars	1	—	—
		E oblongus Sars	2	—	—
		Augaptilus longicaudatus (Claus)	1	—	—

Sta.	Approximate depth of net. (m.)	Species.	♀.	♂.	juv.
172 (*cont.*)	850 (*cont.*)	*Haloptilus chierchiæ* (Giesbrecht)	2	—	—
		H. ornatus (Giesbrecht)	1	—	—
		H. oxycephalus (Giesbrecht)	1	—	—
		H. validus Sars	1	—	—
		Arietellus simplex Sars	1	—	—
		Pachyptilus eurygnathus Sars	1	—	—
		Candacia pachydactyla (Dana)	—	1	—
		Labidocera acuta (Dana)	2	2	—
		Pontella securifer Brady	1	—	—
		Pontellopsis armata (Giesbrecht)	1	—	—
		P. regalis (Dana)	1	—	—
		Copilia mirabilis Dana	—	12	—
	2091	*Calanoides patagoniensis* Brady	—	—	2
		Megacalanus princeps Wolfenden	—	—	2
		Rhincalanus cornutus, f. *typicus* Schmaus	1		—
		R. nasutus Giesbrecht	11		—
		Valdiviella insignis Farran	2	—	—
		Paraeuchæta hanseni (With)	1	—	—
		Pleuromamma xiphias (Giesbrecht)	1	—	—
		Lucicutia challengeri Sewell	1	—	—
		Hemirhabdus grimaldii (Richard)	1	—	—
		Euaugaptilus magnus (Wolfenden)	1	—	—
186	250	*Eucalanus elongatus* (Dana)	191		—
		Rhincalanus cornutus, f. *typicus* Schmaus	1		—
		R. nasutus Giesbrecht	167		—
		Euchirella bella Giesbrecht	4	—	—
		Pontella securifer Brady	1	—	—
	575	*Eucalanus elongatus* (Dana)	830		—
		Rhincalanus cornutus, f. *typicus* Schmaus	12		—
		R. nasutus Giesbrecht	361		—
		Gætanus kruppi Giesbrecht	4	1	—
		Euchirella maxima Wolfenden	3	—	—
		E. orientalis Sewell	23	2	3
		E. pulchra (Lubbock)	—	2	—
		Chirundina indica Sewell	6	—	—
		Euchæta tenuis Esterly	18	3	—
		Paraeuchæta investigatoris Sewell	6	1	—
		Scottocalanus dauglishi Sewell	4	5	—
		Heterorhabdus spinifrons (Claus)	4	1	—
		Heteroptilus acutilobus Sars	2	—	—
	600	*Megacalanus* sp.	—	—	—
		Eucalanus attenuatus (Dana)	67	74	—
		E. elongatus (Dana)	2,741	8	—
		Rhincalanus cornutus, f. *typicus* Schmaus	10		—
		R. nasutus Giesbrecht	1,137		—
		Gætanus kruppi Giesbrecht	42	1	3
		Euchirella galeata Giesbrecht	10	—	2
		E. orientalis Sewell	62	5	—
		E. pulchra (Lubbock)	—	3	—
		Undeuchæta bispinosa Esterly	6	—	—
		Paraeuchæta investigatoris Sewell	61	14	—
		P. weberi A. Scott	2	—	—
		Scottocalanus dauglishi Sewell	56	21	—
		Lophothrix frontalis Giesbrecht	2	—	—
		Pleuromamma xiphias (Giesbrecht)	32		—
		Euaugaptilus magnus (Wolfenden)	1	—	—
	960	*Chirundina indica* Sewell	44	—	—
		Euchæta tenuis Esterly	26	2	—
		Pleuromamma xiphias (Giesbrecht)	33	42	—

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STYLASTERIDÆ (HYDROCORALS) OF THE JOHN MURRAY EXPEDITION TO THE INDIAN OCEAN

BY

HJALMAR BROCH, Ph.D.,
Professor at the University of Oslo.

WITH ONE PLATE AND FOUR TEXT-FIGURES

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Although the John Murray Expedition only brought home a very small collection of Stylasteridæ from the Indian Ocean, the observations present features of considerable interest. Geographically a couple of new localities have been added to our scanty knowledge of the western parts of the Indian Ocean, and although only four species have been dredged, no less than three of them are new to science.

The following species have been collected :

Stylaster (Eu-Stylaster) ramosus n. sp., 73–165 m.
Stylaster (Eu-Stylaster) lonchitis n. sp., 113 m.
Crypthelia stenopoma Hickson and England, 1905, 229 m.
Crypthelia clausa n. sp., 609–915 m.

Neither in the Pemba Canal nor at the Maldives have Stylasteridæ been found previously, and, moreover, the reported localities of the John Murray Expedition are at the present day the most northern localities of the western Indian Ocean from which Stylasteridæ have as yet been reported.

Whereas the two **Stylaster** species from the Pemba Canal have been collected in that zone of the bathymetrical region, where the genus is known to be comparatively abundant in all seas, the localities of **Crypthelia** at the Maldives belong to the uppermost parts of its habitat, and its occurrence in these depths seems to be very scanty. The depth of 229 metres (St. 157) is altogether the shallowest record of the genus at present, and the find is the more surprising because the species which has been found at such a relatively shallow depth, **Crypthelia stenopoma**, has hitherto only been taken in 1300 metres or deeper in the Indo-Malayan Seas. Moreover, this species must evidently be comparatively abundant at the Maldives, several colonies having been brought home from the two stations 152 and 157.

It is very surprising that none of the present species coincide with those reported from the Percy Sladen Trust Expedition to the Indian Ocean (Hickson and England, 1908), which operated in adjacent waters, and the only previously known species, viz. **Crypthelia stenopoma**, has hitherto only been found by the " Siboga " Expedition in the eastern parts of the Indo-Malayan area. This illustrates how scanty our knowledge of the bottom fauna of the Indian Ocean, in fact, is, and it also gives support to the statement in an earlier paper (Broch, 1942) that most species of the Stylasteridæ have a comparatively limited occurrence. Nevertheless, many new localities of Stylasteridæ will probably turn up by-and-by also in the western Indian Ocean, although the occurrence of this (animal) group on the whole is scanty and is confined to special conditions of the sea bottom, which only too often present a severe obstacle to dredging operations in general. In this connection it is of interest to keep in mind that the rich Stylasterid fauna of the waters near Mauritius and South Africa has only quite recently been revealed by the dredging operations of the Danish zoologist, Dr. Th. Mortensen (see Broch, 1936, 1942). It is improbable that Stylasteridæ should be entirely absent in the Red Sea, the Persian Gulf and in the adjacent parts of the Indian Ocean, from which areas as yet no findings have been recorded.

Genus **STYLASTER**.

Two representatives of the **Eu-Stylaster** group are present in the collections. They distinguish themselves at once from the **eximius**-group by their low numbers of dactylopores in the cyclosystems, in spite of many points of resemblance in other respects. **Stylaster eximius**, however, has generally from 12 to 14 dactylopores in the cyclosystems (comp. Broch, 1936), whereas the dactylopores of the two present species commonly only amount to 7 to 11, as the tables show. It is surprising to find this conformity between the two species, which otherwise are rather different. Both show the lowest numbers known among the **Eu-Stylaster** species, and it is only the Japanese species, **Stylaster dentatus** Broch, which has a correspondingly low number of dactylopores ; but this species differs markedly in all other respects.

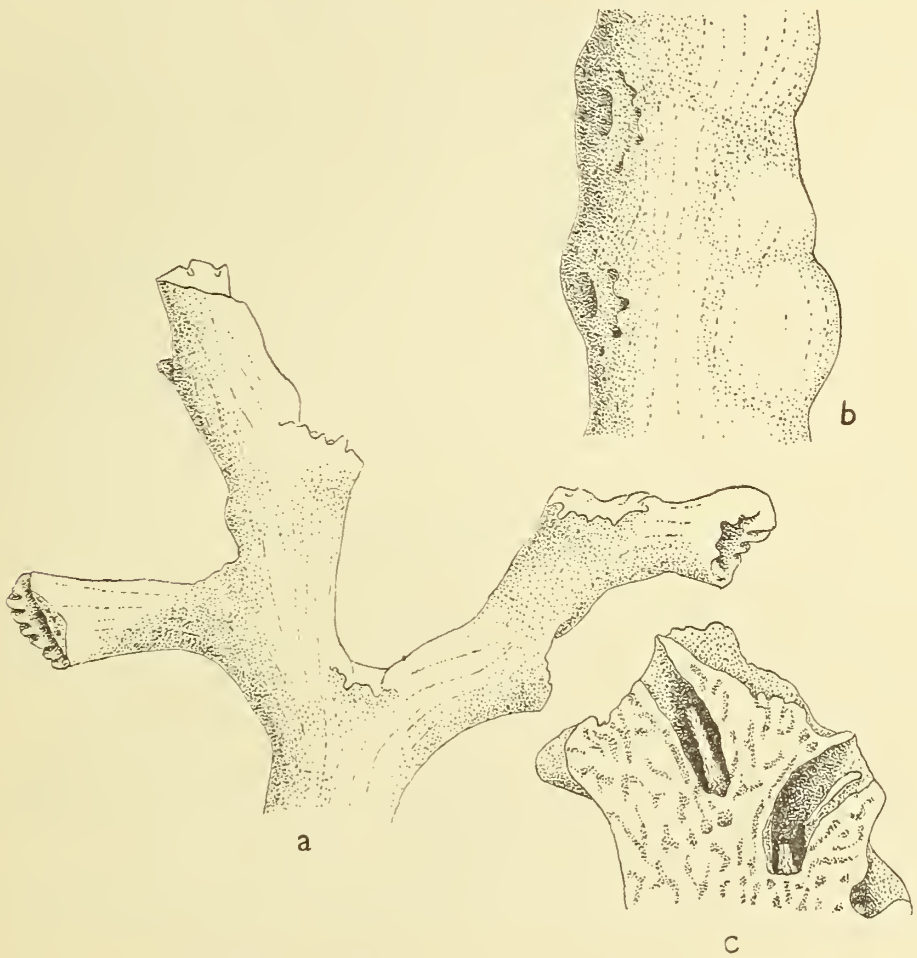
Stylaster (Eu-Stylaster) ramosus n. sp.

St. 111, Pemba Channel, 73–165 m. Several colony fragments up to 42 mm. high.
St. 112, Pemba Channel, 113 m. Very many colony fragments; the largest fragment is 52 mm. high, with a breadth of 48 mm.

The species is reprsented in the collections by a great number of rather large colony fragments, but only a couple of evidently intact colonies are present. The present material seems to indicate that the colonies generally are rather small.

The colonies (Plate I, fig. 1, *a*, *b*) are usually flabellate and very irregularly branched ; in most cases no branch or branchlet diverges from the main plane of the fan. However, two small and evidently intact colonies exhibit an aberrant appearance, as their ramification does not confine itself to one main plane. This is especially obvious in the smallest of the colonies, which is seated on the dead axis of an Antipatharian. The " basal part " of the **Stylaster** covers the Antipatharian axis for some length, and from this incrusting part branchlets and secondarily ramified branches arise in all directions, giving the entire

colony a thoroughly irregular, bushy appearance. Also in a couple of the fragments one branch or other diverges strongly from the main plane of the fan. Although the species, as a whole, must be characterized as fan-shaped, the colonies are, accordingly, not so strictly confined to one plane in their ramification as in many other species of the **Eu-Stylaster** group.



Text-fig. 1.—**Stylaster (Eu-Stylaster) ramosus** n. sp. (*a*) Terminal part of a branchlet. (*b*) Part of a branchlet with ampullæ; on the right side three ampullæ are plainly visible. (*c*) Section exposing the gastrostyles in the gastropores; in the middle gastropore also the basal openings of the dactylopores are seen. (*a–c* × 25.)

In some cases the dimensions of the branchlets and branches are about equal and the colonies are very slender. In other cases, again, the main branches (or stems) are much thicker than the peripheral branchlets and the colonies are thus more robust. Slender colonies have single ampullæ scattered on the branches and branchlets. In some of the robust colonies, on the other hand, the branches and even some of the peripheral branchlets are swollen and inflated by the very numerous, crowded ampullæ; also in these cases the main branches and stems often exhibit comparatively large dimensions, although ampullæ do not occur here.

The species may in some cases be incrusting. This is observed in the basal parts of some of the fragments. The incrusting nature is in one case demonstrated by a seemingly rather robust " main stem " or " main branch," the central part of which consists of the black axis, about 1 mm. thick, of a Gorgonarian ; this axis is covered by a crust, about 1 mm. thick, formed by the **Stylaster**, and the entire " stem " thus attains a diameter of some 3 mm. The same diameter has also been reached in the stoutest branches of other fragments, where, however, no such foreign axis is present.

The surface of branches and branchlets is longitudinally feebly striped (Text-fig. 1, *a*, *b*). This striation is only observed under the lens, and is evidently mainly an optical phenomenon caused by very shallow and narrow furrows, in the bottom of which the numerous, slit-like apertures of the canal meshwork of the cœnosteum debouch. The colour of the colonies (in alcohol) is a pure white or yellowish white.

The *cyclosystems* are, almost without exception, complete. Only in one or two cases a cyclosystem near the summit of a branchlet has a small, cauline interval in the dactylopore circle. On the distal part of the branchlets the plane of the aperture of the cyclosystem forms an angle of some 60° with the axis of the branchlet. Proximally on the branches the aperture plane very soon approaches that of the branch surface, and at the same time the surrounding elevation of the cyclosystem is smoothed, so that the cyclosystems of the branches only present themselves as round gastropores surrounded by circlets of small, round dactylopores. The dactylotomes, which are well developed in young cyclosystems, become filled out in older cyclosystems and ultimately disappear. The diameter of the cyclosystem may amount to about 0·6 mm.

The number of dactylopores in the cyclosystem is illustrated by the following table :

Number of dactylopores in the cyclosystem	6.	7.	8.	9.	10.	11.	12.	13.	
Number of cyclosystems	2	11	28	27	18	11	2	1	100

The average number—8·94—is thus the lowest which has up to the present been recorded in the **Eu-Stylaster** group (comp. Broch, 1936).

The *gastropore* is seldom as deep as 1 mm. It is generally rather strongly and evenly arched, so that its gastrostyle is not visible from without. The gastrostyle (Text-fig. 1, *d*) is slender, needle-shaped, and, especially on its distal part, covered by small spicules, which, however, are not very bristling.

The *dactylopores* lack dactylostyles. In young cyclosystems distally on the branchlets the dactylopore is connected distally with the gastropore by a shallow, but distinct, dactylotome, which, however, is soon obliterated by growth of the cœnosteum. On the other hand, some of the dactylopores basally communicate with the gastropore through an opening in the gastropore wall near the basis of the gastrostyle, a peculiarity hitherto not found in any other **Stylaster.**

The *ampullæ* generally occur in crowded assemblies on smaller branches and branchlets, but not in main branches or stems. In a few cases they are observed singly and in small numbers in very slenderly built colonies. In these cases the ampulla protrudes on the surface of the branchlet almost like one half of a globe ; but in the common, crowded assemblies (Text-fig. 1, *b*) the ampullæ do not protrude so strongly, although this is probably due to a general inflation of the branchlet caused by the lively formation of gonophores. The surface of the ampullæ does not differ essentially from that of the

branches elsewhere in structure; at most the striation is a little less obvious on the ampulla roof.

The soft parts are lacking in the present colonies. Only in a few places remnants of a couple of ampullæ seem to indicate that the specimens are females.

The present species is evidently rather abundant in places, where its special demands are satisfied. The collections contain a great bulk of fragments from the stations 111 and 112, although no specimens have been dredged in other localities.

An investigation of the cœnosteum shows that this has a comparatively loose structure and a rather soft consistency; it is accordingly easily polished. The calcareous substance is also less translucent than in species with harder cœnosteum.

These features are in good accord with the tendency towards incrustation in the species. It is in this connection very interesting that one of the larger fragments in part has a tube-shaped stem, and that two smaller fragments have their stems built in just the same way as **Crypthelia stenopoma** and other Stylasteridæ, which commonly are inhabited by commensal Polychæts. **Stylaster ramosus** is thus evidently (at all events) a possible facultative host of worms. Also Cirripeds (**Pyrgoma**) commonly choose their abode in colonies of the present species (see Plate I, fig. 1, *b*), and also this seems to some degree to be in accordance with its tendency towards incrusting and the entire structure of its cœnosteum.

Stylaster (Eu-Stylaster) lonchitis n. sp.

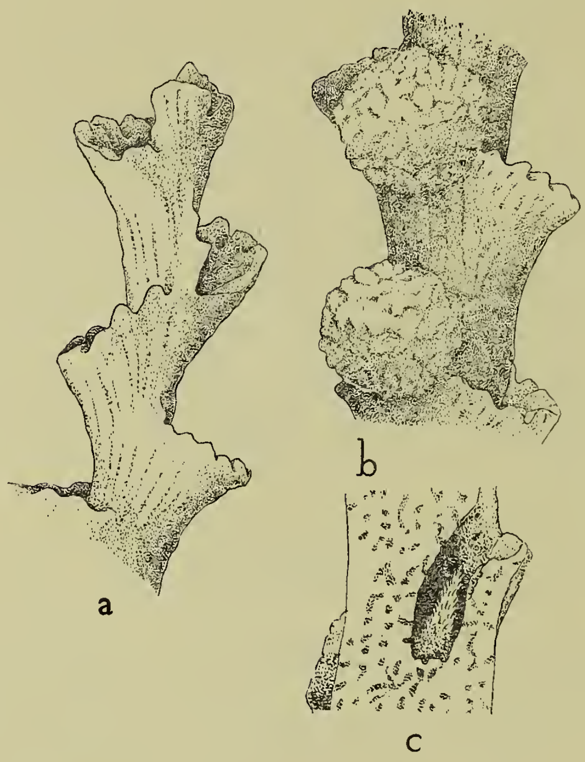
St. 112, Pemba Canal, 113 m. One colony and a few small fragments.

One colony of about 5 cm. height (Plate I, fig. 2) is present, together with some few small fragments. It is impossible to give exact measurements, the colony being very irregularly built; moreover, its basal part is covered by a sponge and carries worm-tubes and small crusts of Bryozoan colonies. One main branch is broken off near its origin and has the same diameter as the stem, which is up to 3 mm. thick. The ramification is scanty and wholly irregular, and the terminal branchlets are long, often more than 1 cm. without indications of side branchlets. Some of the fragments, however, indicate a more regular approximately subdichotomous branching in one plane, and it is likely that this is the normal feature of the species, although the terminal, undivided branchlets also in this case are remarkably long.

The colony is very slenderly built; the dimensions of branches and stem only increase very slowly as compared with the terminal branchlets. The surface of the cœnosteum is longitudinally rather distinctly striped, somewhat like the preceding species, owing to narrow and not very deep furrows, in the bottom of which slit-like openings of the canal meshwork are present. The colonies are (in alcohol) light salmon-pink in colour.

The *cyclosystems* are incomplete, and are horseshoe-shaped. Only in one or two cases terminal cyclosystems were observed, which are complete and circular, with no hint of a diastemma. In all other cases there is a broad, cauline interval in the circlet of dactylopores, and the width of this diastemma increases during growth, although the number of dactylopores seems to be constant in the cyclosystem. Only on the main branches the numbers of dactylopores sometimes evidently diminish during the last phase, when the pores by degrees are filled in and disappear because of the growth of the cœnosteum.

The diameter of the cyclosystems is rather variable. Radially to the branchlet the diameter is seldom as long as 0·6 mm., whereas the larger diameter, tangentially to the branchlet, may even slightly surpass 1 mm. and almost equals the diameter of the rather larger branchlets. The marginal part of the cyclosystem is feebly everted, and the width can accordingly even slightly surpass that of the thinner branchlets.



TEXT-FIG. 2.—**Stylaster (Eu-Stylaster) lonchitis** n. sp. from St. 112. (*a*) Terminal part of a branchlet. (*b*) Part of a branch showing two ampullæ. (*c*) Section through a gastropore exposing its gastrostyle. (*a–c* × 25.)

The number of dactylopores in the cyclosystems is illustrated by the following table :

Number of dactylopores in the cyclosystem	7.	8.	9.	10.	11.	12.	
Number of cyclosystems	3	6	14	17	8	2	50

Although only 50 cyclosystems could be counted, the result is probably representative. The average number—9·54—is a little higher than in the preceding species, and coincides with that stated to be present in the species **Stylaster (Eu-Stylaster) dentatus** Broch from Japanese waters.

The *gastropore* is seldom more than 0·75 mm. deep, but its bottom is connected with somewhat wider canals of the cœnosteum meshwork, which seem to form a continuation of the gastropores, and which occupy the central part of the branchlet. Although the pore is only feebly arched (Text-fig. 2, *c*), the gastrostyle is generally not observed on external examination. The latter is rather robust, slenderly conical, and armed with small, bristling spicules on its distal two-thirds. The gastrostyle has throughout a delicate filigree build. On the basal parts of the gastrostyle wall warty protuberances are often

observed, and in some cases they form a circlet giving the impression of a " basal chamber " in the gastropore.

The *dactylopores* are furnished with distinct dactylostyles. A shallow dactylotome distally connects the pore with the gastropore ; but there is no connection basally with the latter.

Ampullæ have only been found singly on the anterior or posterior side of the branchlets and branches. They are very prominent, and can even form a little more than one half of a globe above the surface of the branch. Remains of the soft parts contained in the ampullæ seem to indicate female specimens. The surface of the ampulla (Text-fig. 2, *c*) is strongly corrugated.

Remains of the soft parts could only be found in the ampullæ, and nothing could be stated as to the structure of gastrozooids and dactylozooids.

The cœnosteum of the present species consists of a comparatively hard calcareous substance, which is slightly more porcellaneous than in the preceding species. There was nothing to indicate that the present species is inclined to incrustation, and also nothing indicates that it affords abode to commensal animals of any kind.

Genus **CRYPTHELIA**.

Crypthelia stenopoma Hickson and England, 1905.

Hickson and England, 1905, Stylasterina of the " Siboga " Expedition, p. 24, pl. iii, figs. 30, 31 and 32.

St. 157, Maldive Islands, 229 m. Several dried, small colonies.

St. 152, Maldive Islands, 609–915 m. A large fragment of one colony and one old, corroded colony, together with **Crypthelia clausa**.

Several small colonies in the collections evidently belong to this species (a note added to the sample from Station 157 by Dr. Sydney J. Hickson also suggests that the specimens must probably be referred to **Crypthelia stenopoma**). There are, however, some small discrepancies as compared with the descriptions given by Hickson and England (1905), and especially the present, dried specimens do not exhibit the small nematophores mentioned by the above-named authors. This, however, may be due to the state of preservation, such details as nematophores being extremely difficult to detect when dried. However, no nematophores could be seen in the large fragment from Station 152, which is preserved in alcohol. This feature does not seem to be of great taxonomic importance.

Hickson and England say that " The surface is marked by pronounced longitudinal and fine transverse striations." A longitudinal striation is only obvious in the thinner branches, and depends upon shallow, somewhat irregular, longitudinal furrows in the bottom of which the peripheral radiating canals of the cœnosarcal meshwork debouch. There is, on the other hand, no trace of a transverse striation in the specimens. To this it may be added that the incrusting parts of the colonies and the ampulla roofs show no traces of striation at all, but exhibit a distinctly porous surface. Here the peripheral, radiating pores of the meshwork are a little dilated in their terminal portion at the surface, and much wider than elsewhere in the colonies.

Hickson and England characterize the species as " partially encrusting." This also holds good in the numerous small colonies of the present collections. However, another

feature is even more obvious, viz. the inflated state of the main stem. The colonies have a structure similar to that of **Stylaster gracilis** and the **Conopora** species that are inhabited by commensal Polychæts (comp. Broch, 1936). The main stem is strongly swollen and hollow, and in some cases it has developed leaf-like projections curving in over one (the posterior) side of the stem. In one case also the worm was present in the tube, and no doubt can exist that the peculiar construction of the stem is caused by the same

Text-fig. 3.—**Crypthelia stenopoma** Hickson and England from St. 157. Branchlet with ampullæ at the bases of the two uppermost cyclosystems. (× 25.)

factors as in the other above-mentioned species that are inhabited by worms. It is thus probable that **Crypthelia stenopoma** also normally is inhabited by worms. The worm had dried up, but is evidently closely related to **Lagisca irritans** v. Marenzeller, which lives in **Stylaster (Stenohelia) macrogaster** v. Marenzeller and **Errina macrogastra** v. Marenzeller (see v. Marenzeller, 1904).

Crypthelia stenopoma (Text-fig. 3) is delicately built with small cyclosystems, the diameters of which only in very rare instances surpass 1·5 mm. The lid is small, in many cases almost rudimentary, and one might sometimes be tempted to refer smaller fragments to **Conopora**, as the lid is only indicated as a somewhat stronger " tooth " between two dactylotomes (see Text-fig. 3). The species exhibits on the whole evidence of a close relationship between **Conopora** and **Crypthelia.**

The number of dactylopores in the cyclosystems is shown in the following table :

Number of dactylopores in the cyclosystem	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
Number of cyclosystems	1	1	2	3	5	12	20	23	20	9	4	—	100

The table shows that the numbers of dactylopores in the cyclosystems are rather great, and seem to coincide remarkably well with the numbers in **Crypthelia pudica** M.

Edwards and Haime (comp. Broch, 1936). The average number in **Crypthelia pudica** is 15·85 (only 40 systems have been counted), in **Crypthelia stenopoma** 15·56. Between these values **Conopora tenuis** Moseley comes in with 15·67 (128 cyclosystems), whereas **Conopora major** Hickson and England only has an average of 13·22 (72 cyclosystems). Also these numbers speak in favour of a " bridge " between the two genera from species of **Conopora**, where one or two of the (proximal) septæ or teeth between the dactylotomes are, in many cases, more strongly developed than the others, to **Crypthelia stenopoma** or allied species with very small lids, which in some cases might almost be regarded as merely excessively developed proximal teeth (or septæ).

The peripheral branchlets of **Crypthelia stenopoma** are very slender in comparison with the strongly inflated stem inhabited by the worm (Plate I, fig. 3, *a–d*), and such branchlets, which are not swollen owing to the development of ampullæ, exhibit an obvious, longitudinal striation, depending on shallow furrows in the bottom of which the apertures of the peripheral, radiating canals of the meshwork are seen as minute pores.

The cyclosystems are generally facing one way, the colonies in these cases exhibiting a pronounced anterior side. We get the impression in these cases that the worm originally has chosen its abode on the posterior side of the stem, which has accordingly developed lateral protecting leaflets curving in over the posterior side. These leaves coalesce to build a somewhat thinner roof over the " tube " of the worm. Secondarily, cyclosystems can also now develop on the posterior side of this roof, and now and again also branchlets can develop in varying numbers with cyclosystems facing the posterior side of the colony. In extreme cases it is very difficult, if at all possible, to distinguish the primarily anterior and posterior side of the colony.

Ampullæ are developed round the bases of the cyclosystems (Text-fig. 3), causing an obvious swelling of the branchlet. On these swellings the striation fades away, but the surface on the other hand here has much larger pores than elsewhere, the peripheral pores having evidently become somewhat dilated. The sex of the colonies cannot be stated with certainty, but the size of the ampullæ seems to indicate that they are females.

The ampullæ are in the present colonies always seated on the anterior side of the branchlet, and at the proximal side of the cyclosystem at the base of the lid, but never in the lid itself.

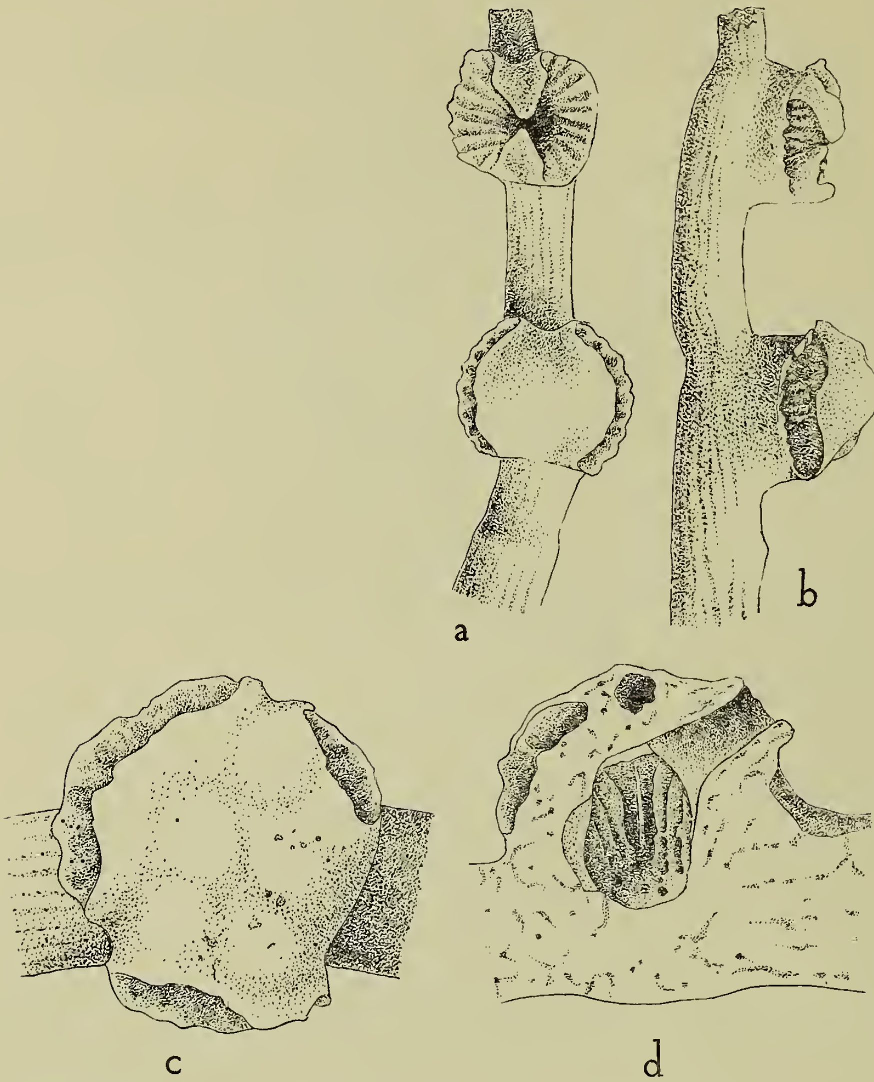
Crypthelia stenopoma had previously only been reported from two localities in the Indo-Malayan Archipelago, viz. N. of Ceram (2° 24·5′ S., 129° 38·5′ E.) and between Lucipara and Schildpad Islands in the Banda Sea (5° 26·7′ S., 127° 36·5′ E.), where it has been met with in depths between 1300 and 1633 m. The present find in only 229 m. depth (St. 157) is therefore very surprising, and it is moreover the shallowest find of the genus altogether. Also the other find in 609 to 915 m. depth is much shallower than the previous records of the species.

Crypthelia clausa n. sp.

St. 152, Maldive Islands, 609–915 m. Two colonies together with **Crypthelia stenopoma.**

The largest colony—the type specimen (Plate I, fig. 4)—is 38 mm. high and 52 mm. broad, and is intact and fixed to a small piece of dead coral. The other, somewhat smaller colony is incomplete. The colony is flabellate, with a comparatively straggling and

slightly irregularly dichotomous branching, and it has a distinct anterior side bearing all the cyclosystems, whereas the posterior side is devoid of cyclosystems. A cyclosystem is always present at the point of origin of the secondary branches on the anterior side of the fork.



Text-fig. 4.—**Crypthelia clausa** n. sp. from St. 152. Type specimen. (*a*) The two terminal cyclosystems of a branchlet in anterior view; in the utmost one the incipient formation of the lid is seen as two opposite "tongues." (*b*) The same cyclosystems in side view. (*c*) Cyclosystem with the lid fixed to the periphery of the cyclosystem by three bridges. (*d*) Section through the same cyclosystem showing ampullæ in the lid. (*a* and *b* $\times$ 9, and *c* and *d* $\times$ 12.)

The surface of the branches exhibits a rather obvious and coarse, longitudinal striation, depending on shallow furrows, in the bottom of which the radiating end canals of the meshwork debouch as small pores. Otherwise the surface is quite smooth, and no nematophores could be seen on the branches or on the lids of the cyclosystems. The calcareous substance is rather hard and snowy white in branches treated with sodium hypochlorite.

Also specimens preserved in alcohol with their soft parts intact are white or, generally, feebly yellowish.

The *cyclosystems* are remarkably large and may, in extreme cases, attain a diameter of 4 mm. ; but in most cases the diameter is between 3 and 3·5 mm. The edge of the cyclosystem is not everted (Text-fig. 4, *b*). It is in most cases impossible to count the dactylopores without demolishing the lids. In two cases, however, 18 and 22 dactylopores could be stated with certainty, the number thus evidently being somewhat larger than in **Crypthelia pudica** and **Crypthelia stenopoma.**

In fully developed cyclosystems the lid covers the cyclosystem almost entirely, like a somewhat irregularly dome-shaped roof. It is fixed to the margin of the cyclosystem in two or generally three places, exceptionally even in four, and the margin shows slight incurvations at the place of fixation when viewed from above (Text-fig. 4, *a* and *c*). The margin is not especially exsert, and not nearly so crenate in side view as in the preceding species.

The lids are as yet quite small in the youngest cyclosystems terminally on the branchlets (Text-fig. 4, *a*, *b*). It is here observed that the lid is formed from two or three (rarely four) sides of the cyclosystem, and that these separate and primarily tongue-shaped formations later on during their growth coalesce into one lid covering almost the entire cyclosystem. The lateral sides of the incipient, tongue-shaped lid formations are at first reflected somewhat upwards, but after the coalescence the lid attains a somewhat uneven convex upper surface.

In most cases the lid almost entirely covers the cyclosystem, so that the niches of the dactylozooids can only be seen along its free borders ; but in a few instances, although these cyclostems are seated on the older parts of the branches and accordingly are rather old, the lid forms only a comparatively narrow bridge over the opening, covering about one half of it. Here, as in other species of the genus, the dimensions of the lid are thus liable to great variations.

The *ampullæ* are developed in the lid, which is rather thick (Text-fig. 4, *d*). In the type colony (possibly a male) the lid contains several ampullæ. In the fragment of the other colony only one ampulla occurs in the lid. Here one cyclosystem was sacrificed for an investigation of the soft parts. As to the ampulla, it turned out that the colony was a female. The large, almost mature egg rests in a cupshaped trophodisc consisting of a large number of blind sacs.

Evidently the *gastropolyp* is devoid of tentacles. The *dactylopolyps* are rather large and finger-shaped, but without any central lumen. They are fixed to the wall of the dactylopore near the upper edge of the cyclosystem, and have a small, almost terminal adhesive part. No traces of nematophores could be detected in the sections. This is also in accordance with the external examination of the colonies, as mentioned above.

The present colonies no doubt belong to a species of **Crypthelia** which has not hitherto been recorded in the literature. The very large dimensions, especially of the cyclosystems, and the remarkably coarse build of the colonies on the whole at once attract the attention, and although the dimensions alone do not suffice as a specific criterion, they evidently support other and deciding features, such as the remarkable construction of the lid.

In all other species of **Crypthelia** that have been reported the lid is a single formation (although an anomaly was observed in one or two cases in **Crypthelia stenopoma**, where two opposite lids were found in the cyclosystem). But in **Crypthelia clausa** the lid is in

its origin normally a composite formation arising from two or three (exceptionally even four) individual lid-tongues growing out from the margin of the cyclosystem and later on coalescing into one lid. In all other previously known species of the genus the lid is only fixed to the margin of the cyclosystem by one hold.

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DESCRIPTION OF PLATE I.

Fig. 1.—*Stylaster* (*Eu-Stylaster*) *ramosus* n. sp. (*a*) Type specimen from St. 112. (*b*) Another specimen from the same station, infested by two Cirripeds (*Pyrgoma* sp.).

Fig. 2.—*Stylaster* (*Eu-Stylaster*) *lonchitis* n. sp. Type specimen, nat. size.

Fig. 3.—*Crypthelia stenopoma* Hickson and England. *a* and *b*, Two colonies seen from the anterior side. *c* and *d*, Two other colonies seen from the posterior side, nat. size.

Fig. 4.—*Crypthelia clausa* n. sp. Type specimen from the anterior side, nat. size.

a *b*

FIG. 1.

FIG. 2.

a *b*

c *d*

FIG. 3.

FIG. 4.

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WITH TWENTY-FOUR TEXT-FIGURES AND TWO CHARTS.

HISTORICAL.

One of the earliest attempts to provide an adequate explanation of the distribution of the Copepoda and other Crustacea is that of Dana (1853), who, however, dealt with the Crustacea as a whole and thus included many forms that are not planktonic except in their larval stages. He constructed a chart in which the surface of the oceans is divided into zones by what he terms "isocrymal" lines : these are lines of equal surface temperature during the coldest thirty consecutive days of the year, as opposed to "isothermal" lines that are based on summer or winter temperature or on the average temperature in any given month of the year. Semper (1883) recognized that oceanic currents may serve as means for the distribution of species, but may also act as limiting factors hindering their extension ; but he also further recognized that these results may be modified or even be completely abolished by other factors, so that planktonic organisms may be carried by currents into unfavourable regions, where they are destroyed, and he points out that "many animals are susceptible to variations of temperature, consequently, if any warm-water animals are borne by a current from the region of warm seas into a cold one, they must in all probability perish very soon." Chun (1886) agrees with Semper, and considers that currents and winds of constant duration may assist in the horizontal distribution of pelagic organisms, but he also considers that they may in many instances act as impassable barriers.

Since that date many authors have attempted to correlate the distribution of most of the various forms of planktonic organisms with the surface currents, and an especially noteworthy attempt was that of Pelseneer (1887), in which he divided the oceanic surface into as many as ten Provinces, each connected with a definite current system ; and he gave it as his opinion that "each great surface area of water coinciding with an important current or system of currents forms a distinct pelagic province." Giesbrecht (1892), however, only recognized three zones of distribution among the Copepoda, namely an Arctic zone, extending southwards to about Lat. 47° N., which is poor in the number of species ; a warm tropical and subtropical zone, which is rich in species ; and an Antarctic Zone that extended northwards to about lat. 44° S., that also is poor in species. He did, however, recognize that the northern region must be subdivided into Atlantic and Pacific sub-regions. Although he was convinced that the main factors in delimiting these three regions were temperature and light, he refused to admit that the ocean currents could be considered as forming faunistic regions, so far as the Copepoda were concerned, and he based this view on the fact, firstly, that as many as 32 per cent. of the warm-water species,

known at that time, were common to both the Atlantic and Pacific Oceans, in spite of the fact that they are separated by the American continent, and second, that the " Gulf Stream," of which the eastern part is one of the best known regions, was intersected by the " barrier " between his warm and cold north faunistic regions. Although Fewkes (1888) had put forward the suggestion that " the differences in temperature of the surface of the ocean is one of the most important factors in determining the character of pelagic organisms. . . . When the temperature of the deep sea becomes a surface temperature, we may look for allies of deep-sea animals," Giesbrecht concludes that his three faunistic regions hold good not only for surface-living species but also for those living in the deep strata, and he remarks that " one does not meet with the deep-sea species of warm seas even among the arctic species " ; he does, however, admit that the oceanic currents may bring about local and temporary inequalities in the distribution of the species.

The following year Haeckel (1893), in his " Plankton Studies," put forward the view that " by far the most important of all the causes which determine the changing and irregular distribution of the Plankton in the seas are the marine currents," and that " the unequal distribution of plankton in the ocean is in great part the direct result of the ocean currents." Haeckel further recognized that the influence of the currents must be extended to the movements of the deeper layers, which he termed the Bathycurrents, and he remarks, " the Bathycurrents are of great importance for the irregular constitution and distribution of the plankton." Dahl (1894) extended Giesbrecht's scheme of subdivision of the ocean and recognized in the North Atlantic Ocean as many as four separate zones, namely, an Arctic Zone, a Temperate zone, a Sub-tropical zone and a Tropical zone. Dahl clearly points out that the boundaries of his regions do not correspond to geographical latitudes but are determined by the surface currents : thus, as regards his Arctic region, he notes that the characteristic forms are carried to the south in the Labrador Current, while his Tropical region is extended to the north in the Florida Stream.

The schematic subdivision of the surface waters of the oceans has been carried a stage further by Steuer (1933). In this paper he has given a map indicating the subdivisions of the oceans into no less than seven zones in the Atlantic and Pacific areas and five in the Indian Ocean, and we thus have the following zoo-geographical areas :

I. A circum-polar Arctic region.

II. A sub-arctic zone, subdivided into
(A) an Atlantic sub-region, and
(B) a Pacific sub-region.

III. A sub-tropical zone, subdivided into
(A) a North Atlantic sub-region, and
(B) a Pacific sub-region.

IV. A Tropical zone, subdivided into
(A) an Indo-Pacific sub-region, and
(B) an Atlantic sub-region.

V. A southern Sub-tropical zone, subdivided into
(A) a southern Atlantic sub-region,
(B) an Indian sub-region, and
(C) a south Pacific sub-region.

VI. A Sub-antarctic circum-polar zone, and finally

VII. An Antarctic circum-polar zone.

Of these various regions he regards the circum-polar sub-arctic and sub-antarctic regions as transition zones.

A comparison of this chart (Steuer, 1933, p. 292, fig. 8) with a chart of the surface currents of the great oceans reveals such a close similarity that by applying the one to the other we can at once recognize that each region is in reality a part of a particular current system : the circum-polar Arctic region is the region of the Arctic Ocean with its southward extension down the north-east coast of America in the Labrador current, and there should be a similar extension, not indicated by Steuer, of this region southwards along the north-east coast of Asia past the Kamchatka Peninsula to Japan, corresponding to the Okhotsk or Oya-Shio Currents. Fuchs (1881) pointed out that although the Japan Sea is characterized by a Tropical fauna that can be traced unusually far to the north, namely lat. 42° N., whereas the Okhotsk Sea is typically arctic, certain arctic species penetrate into the Japan Sea, being carried there by the Kurile Current through the Sangar Strait.

The sub-artic Atlantic and Pacific sub-regions correspond with the currents of the Gulf Stream and the North Atlantic Drift in the North Atlantic and the Kuro-Shio and Californian currents in the North Pacific Ocean respectively. The Sub-tropical zone, as Steuer points out, corresponds in the Atlantic with the region of the Sargasso Sea and the Canaries current, and in the Pacific Ocean with the corresponding area enclosed by the clock-wise circulation of the surface currents in that region. The Tropical zone corresponds to the great North and South Equatorial currents, together with the Contra-equatorial current in all three Oceans, the Indian and Pacific regions being interconnected by numerous channels through the Malay Archipelago ; and this zone is extended southwards in the Atlantic Ocean by the Brazil current and in the Indian Ocean by the Agulhas current. The southern Sub-tropical zone corresponds in each of the three oceans with the central and southern regions of the great counter-clockwise movement of the surface water in the southern part of each ocean. The circum-polar sub-antarctic zone corresponds to the West Wind Drift. And, finally, the circum-polar Antarctic zone corresponds to the true Antarctic region. In an earlier work Steuer (1910) remarks that the different zoo-geographical regions of the plankton show a great dependency on the distribution of the ocean currents, so that the distribution of the plankton is directly intelligible from the study of the great circular water movements. Steuer fully recognized that the study of the surface currents of the oceans can only provide an explanation of the distribution of those planktonic forms that inhabit the upper water masses, and that in order to understand the distribution of those species that live at depths greater than some 400–500 m., it is essential to study the movements of the intermediate currents, viz., the North Atlantic and Indian intermediate currents that tend to run from north to south and of the Sub-polar or Antarctic intermediate current that runs in the opposite direction from south to north, and for the inhabitants of the greatest depths, the Antarctic Bottom water.

So far as the surface currents are concerned, the lines along which these come in contact with each other are termed " Convergence lines " or, better, " Convergence zones," and it must be recognized that, though these are shown on charts as lines, this is merely a convenient schematic way of indicating their general position, and that actually where two

such currents meet there is in fact between them a wide belt in which the surface water is moving in a complicated series of vortices ; such a condition is clearly shown in the chart given by Willimzik (1929, p. 23, fig. 6) of the portion of the South Indian Sub-tropical convergence to the south-east of Madagascar. Such vortices cause not only a very considerable degree of admixture of the water masses, but must also carry individuals belonging to different species of planktonic organisms from one mass of water into the other. It must also be recognized that these convergence lines on the surface of the ocean are merely the lines along which the planes, separating one great water mass from another, reach the surface, and that at different depths, where these planes separate one water mass from another, there is also a certain and perhaps a very considerable degree of admixture, that must carry with it some, at least, of the fauna.

In any given area, in which there is a more or less continuous current or series of currents at different depths, we should be able to correlate the distribution of the plankton with the movements of the water masses. Russell (1935, p. 6) has summed up the present position in the following words: " It is probable that in ocean waters one of the main barriers to distribution is that of the temperature conditions. Animals adapted for successful reproduction in any given temperature range will be carried in the water masses and ocean current systems so far as the necessary temperature conditions are maintained. When the temperature conditions have been taken into consideration, the chief clues to the geographical distribution of the species are to be found in the systems of oceanic circulation. . . . Each body of water has its own somewhat characteristic plankton fauna at different levels. These faunas tend to mix at the boundaries." In 1940 (Sewell, 1940*b*) I reviewed the evidence that we possess which indicates the extent to which planktonic organisms and to a less extent the neckton and benthos are influenced in their distribution by the various current systems in the three great oceans ; but, as Redfield (1941) has pointed out regarding the distribution of the plankton in the Gulf of Maine, in many species there is a marked diurnal migration that carries the plankton from one particular layer to another and " consequently the population cannot be identified exclusively with any particular layer, and any attempt to correlate its distribution with the drift of the water is complicated by the undoubted migration of the animals to and from layers of different depth moving with different velocities and in some places without doubt in different directions."

Earlier workers seem to have been impressed somewhat unduly by the degree of similarity between the faunas of the various regions, and especially of the faunas of the tropical and temperate regions of the three great oceans. Giesbrecht (1892) stated that from the knowledge that we then possessed it seemed clear that the faunas of the oceans differ but little from each other in comparison with the marked differences that are found between the faunas of the warm regions and those of the north or south cool areas. F. Dahl (1894) pointed out that the surface-living Copepoda of the tropical regions of the Indo-Pacific Ocean are for the most part the same owing to the free intercommunication that exists between the Indian and west Pacific regions by means of the surface currents ; and Bedot (1909) put forward the view that eupelagic marine animals can circulate freely throughout the whole hydrosphere, allowing themselves to be swept along by the currents, and that such differences as have been found to exist between the epi-pelagic fauna of different regions are only temporary. Steuer (1910), commenting on the work that had up to then been done in the great oceans, remarked that in spite of the comparatively

little that had at that time been achieved in the Indian and Pacific Oceans, "the few observations already allow us to see that both in the Poles and on the Equator a uniform plankton, almost without exception, animates all seas," and he adds that in all areas the number of universally present species increases importantly with the progressive exploration of the high-sea Plankton.

Lohmann (1916) appears to hold the same view as Bedot, for he concludes that a species can live in all oceans and in all latitudes but that it can prosper only in warm water; and Steuer (1933) also appears to agree with this, for he considers that all the various regions and sub-regions into which he has divided the oceans only represent places of optimum conditions and temporary maximal development, and thus are to be regarded merely as regions of plenty, whereas those regions, in which a species has not as yet been taken, are regions of scarcity. He concludes that tropical species may be carried into the Antarctic and that, on the other hand, Antarctic species may be swept by the Antarctic deep currents into the tropical region, and that oceanic plankton may be carried downward into deep water and be transported by the deep currents to great distances; as a result of this he suggests that it may be necessary to compile distribution charts of individual species, not for the whole surface area of the ocean but for each depth-horizon separately, and in his study of different races within the limits of the same species he has indicated that in certain instances it is possible to correlate their occurrence with a particular deep current, as, for instance, he has shown to be the case with two varieties of *Pleuromamma xiphias* (Giesbr.), in which there is a small, warm-water form in the tropical region and a large, cold-water form that inhabits the West Wind Drift; but in the Arabian Sea both races occur, the large form having been carried northwards into the area at a depth of some 700 m. by the Antarctic intermediate current.

INTRODUCTION.

It is customary to subdivide the Copepoda into a series of groups according to the frequency of their occurrence and the increased numbers of individuals present in different habitats. These groups as given by Farran (1920) are (1) *Neritic* species, that are taken in large numbers near the coast; (2) *Oceanic* species, that are usually taken away from the coast in the open waters of the ocean; (3) *Euryhaline* species, that appear to have a wide tolerance to differences of salinity and so may be present in any locality, whether oceanic or littoral; and (4) *Benthic* species, that live on or close to the sea bottom.

Ostenfeld (1931) makes a more detailed subdivision and recognizes (1) Brackish-water species; (2) Littoral and brackish-water species; (3) Neritic, low salinity, species; (4) Neritic species; (5) Atlantic Oceanic species, existing all the year round under neritic conditions; and (6) Atlantic Oceanic species, existing for only part of the year in neritic conditions. F. Dahl (1894*a*) has however pointed out that, although it is possible to recognize a coastal zone as distinct from the general oceanic region, "many coastal forms occur in isolated instances in the high seas and similarly many oceanic forms occur on the coast." Russell (1935) has pointed out that some species coincide with the limits of certain water masses, while others spread over a wide area; and thus we get an overlap between species that can be classified in one or more groups. It must therefore be borne in mind that any such division is not a hard and fast one: a species may, as a rule, be abundant

near the coast and so be classed as "neritic," and yet it may be quite capable of living and reproducing, though perhaps only in small numbers, in the open ocean. Steuer (1933*a*, p. 274) remarks, "Some neritic species are confined solely to the coast, others pass, for instance in the North Atlantic, far out into the open sea." Personally I very much doubt whether "neritic" species are so rigorously confined in their habitat. Indeed it not infrequently happens that a species is regarded by one author as "neritic" and by another as "oceanic"; for instance, *Calanus finmarchicus* (Gunn.) is listed by Farran (1920, p. 16) as a neritic species, but the work of Sars and others has shown that it may be taken all over the North Atlantic Ocean, though frequently at considerable depths. *Pseudocalanus elongatus* (Boeck) is another species that is classed as neritic by Farran (1920) but was regarded as oceanic by Herdman and A. Scott (1912), and *Candacia armata* Boeck (= *C. pectinata* Brady) is such another. *Centropages hamatus* (Lillj.) and *Acartia discaudata* (Giesbr.) are usually taken in inshore waters and so would be classed as "neritic," but Herdman, Thompson and A. Scott (1898) have recorded both these species from the open waters of the mid-Atlantic, and the same is true of *Temora longicornis* (Müll.). *Anomalocera patersoni* Templ. on the other hand is listed as an "oceanic" species by Herdman, Thompson and A. Scott and as a euryhaline species by Farran, yet the chart of its distribution (*vide* Steuer, 1933*a*, p. 276) shows that as a rule it is taken in the vicinity of the coast and especially of the eastern shores of the north Atlantic. Farran (1936) has given a list of species that were taken on the Australian Barrier Reef and that he considers to be "coastal" in their habitat. There are 30 Calanoid species in this list, the names of which I give below:

Canthocalanus pauper Giesbr.
Undinula vulgaris (Dana).
Eucalanus subcrassus Giesbr.
Paracalanus aculeatus Giesbr.
P. parvus (Claus).
Acrocalanus gibber Giesbr.
Clausocalanus arcuicornis (Dana).
Calocalanus pavoninus Farran.
Undinopsis tropicus Wolfend.
Euchæta concinna Dana.
Scolecithrix danæ (Lubb.).
Centropages furcatus (Dana).
C. gracilis (Dana).
C. orsinii Giesbr.
Temora discaudata Giesbr.
Candacia æthiopica Dana.
C. discaudata A. Scott.
Calanopia elliptica (Dana).
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
L. lævidentata (Brady).
Pontella cristata Krämer.
P. danæ Giesbr.
P. fera Dana.
Pontellopsis krameri (Giesbr.).
P. macronyx A. Scott.
P. regalis Dana.
Acartia pacifica Steuer.
Tortanus gracilis (Brady).

But of these 30 species as many as 19 have been taken in open water well out in the Arabian Sea or further south in the Indian Ocean. Farran (*loc. cit.*, 1936) also gives a list of "open sea" species, which includes the names of 38 species that are normally taken at or near the surface, namely:

Calanus tenuicornis Dana.
Neocalanus gracilis (Dana).
Nannocalanus minor (Claus).
Undinula darwini (Lubb.).
Eucalanus crassus Giesbr.
E. mucronatus Giesbr.

Rhincalanus cornutus (Dana).
Mecynocera clausi Thompson.
Paracalanus denudatus Sewell.
Acrocalanus gracilis Giesbr.
A. longicornis Giesbr.
A. monachus Giesbr.
Clausocalanus furcatus (Brady).
C. farrani Sewell.
C. paululus Farran.
Calocalanus plumulosus (Claus).
Euchæta consimilis Farran.
E. longicornis Giesbr.
E. media Giesbr.
E. wolfendeni A. Scott.
Scolecithrix danæ (Lubb.).
Centropages calaninus (Dana).
Temora turbinata (Dana).
Lucicutia flavicornis (Claus).
L. ovalis Wolfend.
Candacia bispinosa Claus.
C. catula Giesbr.
C. curta Dana.
C. longimana Claus.
C. simplex Giesbr.
C. truncata Dana.
Calanopia aurivillii Cleve.
Labidocera minuta Giesbr.
Pontella securifer Brady.
Pontellina plumata Dana.
Acartia danæ Giesbr.
A. negligens Dana.
A. pietschmani Pesta.

But of these species that are "open sea" forms in the Australian region, 28 have been taken on the Ceylon Pearl Banks, 19 in the enclosed waters of Nankauri Harbour in the Nicobar Islands and 16 in inshore waters on the South Burma Coast, and several species occur in all three localities; in all, 35 species out of the total of 38 have been captured in the littoral zone in the Indian Ocean.

In Indian waters some 74 species of Calanoids have up to the present time been taken only in areas that are essentially littoral in character, namely:

**Paracalanus crassirostris* Dahl.
**P. dubia* Sewell.
P. nudus Sewell.
P. nanus Sars.
**P. serratipes* Sewell.
Acrocalanus gardineri Wolfend.
**A. inermis* Sewell.
Calocalanus styliremis Giesbr.
C. contractus Farran.
Macandrewella chelipes (Giesbr.).
M. scotti Sewell.
Scolecithrix danæ (Lubb.).
Scolecithricella nicobarica Sewell.
S. pearsoni Sewell.
**Centropages alcocki* Sewell.
C. dorsispinatus Thomp. and A. Scott.
C. elongatus Giesbr.
C. trispinosus Sewell.
C. tenuiremis Thomp. and A. Scott.
**Pseudodiaptomus annandalei* Sewell.
**P. aurivillii* Cleve.
**P. binghami* Sewell.
P. clevei A. Scott.
P. burckhardti Sewell.
**P. hickmani* Sewell.
P. masoni Sewell.
P. mertoni Früchtl.
P. salinus Giesbr.
**P. serricaudatus* (T. Scott).
**P. tollingeræ* Sewell.
**Isias tropica* Sewell.
Temora discaudata Giesbr.
**Pseudocyclops obtusatus* Brady and Robertson.
**P. simplex* Sewell.
Calanopia aurivillii Cleve.
C. herdmani Thomp. and A. Scott.
C. thompsoni A. Scott.
Candacia bradyi A. Scott.
C. catula (Giesbr.).
C. discaudata A. Scott.

Labidocera bataviæ A. Scott.
**L. euchæta* Giesbr.
**L. gangetica* Sewell.
L. kröyeri (Brady) and its varieties.
L. lævidentata (Brady).
L. maduræ A. Scott.
**L. pavo* Giesbr.
L. pectinata Thomp. and A. Scott.
**Pontella andersoni* Sewell.
P. danæ Giesbr. and its varieties.
P. denticauda A. Scott.
**P. investigatoris* Sewell.
P. princeps Dana.
Pontellopsis herdmani Thomp. and A. Scott.
P. krameri (Giesbr.)
P. macronyx A. Scott.
P. scotti Sewell.
P. strenua (Dana).
**Acartia centrura* Giesbr.
**A. chilkaensis* Sewell.
A. danæ Giesbr.
**A. plumosa* T. Scott.
**A. spinicauda* Giesbr.
A. southwelli Sewell.
**Acartiella gravelyi* Sewell.
**A. kempi* Sewell.
**A. major* Sewell.
**A. minor* Sewell.
**A. sewelli* Steuer.
**A. tortaniformis* Sewell.
Tortanus barbatus (Brady).
T. forcipatus (Giesbr.).
T. gracilis (Brady).
T. tropicus Sewell.

Of the above species 29, marked with an *, appear to be inhabitants of brackish water; and, as one would expect, many such species possess a very high degree of adaptability to changes of salinity. Percival (1929) has shown that the European species *Eurytemora affinis* (Poppe) and *Acartia bifilosa* (Giesbr.) in the estuary of the Tamar River can survive in a range that extends from 0·1 to 33·0 ‰ and 0·3 to 32·0 ‰ respectively. Among the Indian species we also find a very considerable range of adaptability (*vide* Sewell, 1934, p. 110), the full extent of which has not yet been determined, but I give below the ranges of salinity that have been observed in some of these species in Indian waters:

Acrocalanus inermis Sewell	in salinity	ranging	from	0·17	to	33·0 ‰
Labidocera euchæta Giesbr.	,,	,,	,,	2·0	,,	32·65 ,,
Acartia spinicauda Giesbr.	,,	,,	,,	2·0	,,	32·06 ,,
Pontella andersoni Sewell	,,	,,	,,	7·9	,,	32·97 ,,
Paracalanus crassirostris F. Dahl	,,	,,	,,	10·0	,,	33·0 ,,
Centropages dorsispinatus Thomp. and A. Scott.	,,	,,	,,	10·9	,,	32·82 ,,
C. tenuiremis Thomp. and A. Scott.	,,	,,	,,	10·9	,,	32·66 ,,
Labidocera pectinata Thomp. and A. Scott.	,,	,,	,,	10·9	,,	32·84 ,,
Pseudodiaptomis aurivillii Cleve	,,	,,	,,	16·29	,,	32·84 ,,
Candacia discaudata A. Scott	,,	,,	,,	16·29	,,	33·27 ,,
Calanopia thompsoni A. Scott	,,	,,	,,	16·29	,,	33·27 ,,

Among those species that are truly marine, though frequently taken in inshore waters, the range of adaptability is not quite so great. de Lint (1922) gives the range for *Centropages hamatus* (Lillj.) as extending in the Zuiderzee from 23·9 ‰ to as low as 13·5 ‰. A number of species, that are frequently taken in, and may be regarded as characteristic

of, open water, have been captured in inshore waters on the South Burma coast, and here too there appears to be wide range of tolerance to differences of salinity :

Acartia centrura Giesbr.	in salinity ranging from	10·9	to 29·05 ‰
Paracalanus aculeatus Giesbr.	,, ,, ,,	10·9	,, 36·35 ,,
Undinula vulgaris (Dana)	,, ,, ,,	10·9	,, 36·35 ,,
Labidocera minuta Giesbr.	,, ,, ,,	10·9	,, 36·50 ,,
Metacalanus aurivillii Cleve	,, ,, ,,	16·29	,, 32·82 ,,
Acrocalanus gibber Giesbr.	,, ,, ,,	16·29	,, 32·96 ,,
Eucalanus subcrassus Giesbr.	,, ,, ,,	16·29	,, 36·35 ,,
E. monachus Giesbr.	,, ,, ,,	16·29	,, 32·96 ,,
Temora turbinata (Dana)	,, ,, ,,	16·29	,, 33·27 ,,
Centropages furcatus (Dana)	,, ,, ,,	16·29	,, 33·27 ,,
Macrosetella gracilis (Dana)	,, ,, ,,	16·29	,, 36·27 ,,
Paracalanus parvus (Claus)	,, ,, ,,	16·29	,, 36·35 ,,
Canthocalanus pauper Giesbr.	,, ,, ,,	16·29	,, 36·35 ,,
Calanopia elliptica (Dana)	,, ,, ,,	16·29	,, 36·50 ,,
Acartia erythræa Giesbr.	,, ,, ,,	28·48	,, 35·53 ,,

Most of these latter species are of frequent occurrence in these inshore waters, and out of a total of 37 surface tow-nettings taken on the Burma coast in 1913–14, the species given below were identified the following number of times :

Paracalanus aculeatus Giesbr. . . .	33 times.
Temora turbinata (Dana) . . .	27 ,,
Canthocalanus pauper Giesbr. . . .	26 ,,
Acrocalanus gibber Giesbr. . . .	25 ,,
Labidocera minuta Giesbr. . . .	25 ,,
Eucalanus monachus Giesbr. . . .	22 ,,
Centropages furcatus (Dana) . . .	22 ,,
Calanopia elliptica (Dana) . . .	20 ,,
Eucalanus subcrassus Giesbr. . . .	17 ,,
Acartia erythræa Giesbr. . . .	14 ,,
Undinula vulgaris (Dana) . . .	10 ,,
Metacalanus aurivillii Cleve . . .	7 ,,
Acartia centrura Giesbr. . . .	7 ,,
Macrosetella gracilis (Dana) . . .	4 ,,
Paracalanus parvus (Claus) . . .	2 ,,

Out of a total of some 60 surface-living species that have been taken off the South Burma coast the number of oceanic forms is 37, or 60 per cent. I have records of 66 species that have been taken in the region of Nankauri Habour, in the Nicobar Islands and of these 45 are known to occur in the open ocean, or 68 per cent. From the Ceylon Pearl banks 86 surface-living species are known, of which 58, or 64 per cent., are oceanic species. Finally from the Maldive and Laccadive Archipelagoes out of a total of 63 species 46, or 73 per cent., are known to occur in the open ocean. The increase in the percentage of oceanic forms in this latter area is only to be expected in view of its geographical situation, but

the fact that around these coral islands, that have never been connected with the mainland, we still find as many as 27 per cent. of littoral forms equally clearly indicates that these forms must be able to traverse wide areas of open water.

A study of the distribution of the Copepoda compels one to realize that the vast majority of species, including not only those that are classed as neritic but also many of those that are to-day usually found to be inhabitants of brackish-water or estuarine regions, must be, or at some previous time have been, capable of surviving transportation from one inshore region to another and have been carried along by currents, either in-shore or off-shore, across areas that are to-day oceanic in character. Apart from a relatively few brackish-water forms, there are very few species that are confined to a single locality and many are of world-wide distribution ; and even in these brackish water species one is not justified in assuming that their habitat is so sharply localized until much more research has been carried out. That transportation in the past must have had far-reaching effects on the distribution and evolution of related species is indicated by the present-day distribution of the species of the genus *Pseudodiaptomus* (*sensu lato*), which, as is now generally accepted, was originally marine in its habitat, but has succeeded in invading brackish water in many parts of the world and has even become established in fresh water. Marsh (1933) has subdivided this genus into two closely related genera, *Pseudodiaptomus* Herrick (*sensu stricto*) and *Schmackeria* Poppe and Richard, but since the main character used to separate these two genera is to be found in the character of the 5th pair of legs in the male, it is not possible to refer to either genus those species in which only the female is at present known. In the genus *Schmackeria* the great majority of species are to day to be found living in fresh or brackish water, only a single species, *S. sericaudatus* (T. Scott), being truly marine, though this too may occur in brackish water, and having a wide distribution in both the Indian and Atlantic Oceans. As regards the other species that Marsh includes in this genus, we find *Schmackeria inopinus* Burckhardt and *S. forbesi* Poppe and Mrazek, both from fresh-water, in China ; *S. japonicus* Kikuchi, from fresh-water (?), in Japan ; *S. smithi* Wright from fresh-water (?), in the Philippine islands ; *S. poppei* Stingelin, from fresh-water, in Celebes ; *S. nostradamus* Brehm, from fresh-water, in Java ; *S. binghami* Sewell, in fresh- and brackish-water of the estuary of the Rangoon River, in Burma and the Chilka Lake, India ; *S. annandalei* Sewell and *S. tollingeræ* Sewell, in brackish-water, in the Chilka Lake, India ; *S. dubius* Kiefer, in fresh-water (?), at Vizagapatam on the east coast of India ; *S. lobipes* (Gurney) from fresh-water at Calcutta and from the Chilka Lake, in India ; and *S. cornutus* Nicholls, in brackish-water, from the south coast of Australia.

In the very closely related genus *Pseudodiaptomus* Herrick (*s. str.*) there are six, or possibly seven, species that are marine in their habitat, namely, *P. aurivillii* Cleve, *P. clevei* A. Scott, *P. mertoni* Früchtl and *P. salinus* Giesbr. from the Indo-Pacific region, and *P. pelagicus* Herrick from the Atlantic coast of North America and perhaps *P. americanus* Wright from the Gulf of Mexico. The remaining species are from either brackish- or fresh-water, namely *P. dauglishi* Sewell, from brackish-water (?), in Perak, Federated Malay States ; *P. hickmani* Sewell from the south-east coast of Australia (as a variety), and brackish-water of the Rangoon River estuary, in Burma ; *P. stuhlmanni* Poppe and Mrazek, from fresh-water, in East Africa ; *P. hessei* (Mrazek), from brackish-water in the Gulf of Guinea, West Africa ; *P. richardi* (Dahl) and *P. marshi* Wright, in brackish-water on the east coast of South America ; *P. acutus* (Dahl) and *P. gracilis* (Dahl) from brackish

or fresh-water in the estuary of the Amazon River, South America ; *P. cristobalensis* Marsh and *P. culebrensis* Marsh, both from fresh-water, on the east and west sides respectively of the Isthmus of Panama ; and *P. coronatus* Wilson, from brackish- or salt-water in the Woods Hole region of the east coast of North America ; and Johnson (1939) has described a new subgenus and species, *P.* (*Pseudodiaptallous*) *euryhyalinus* from brackish-water in South Carolina. In both these genera the ancestral forms must have become widely dispersed by means of currents that involved a passage from the Indo-Pacific region into the Atlantic Ocean.

A very similar distribution is to be found in the littoral-haunting species *Paracalanus crassirostris* F. Dahl, which has now been recorded from such widely separated localities as the Aru Archipelago (Früchtl) ; the sea off Penang and the mouth of the Karau River, Malaya, the Andaman and Nicobar Islands, the Chilka Lake, India (Sewell) ; the Pearl Banks of Ceylon (Thompson and A. Scott) and the estuary of the Amazon River, South America (Dahl) ; while closely related forms or varieties have been evolved in other areas, such as *P. crassirostris* f. *sewelli* Früchtl (= *P. dubia* Sewell) in the Rangoon River estuary, Burma, and *P. crassirostris* f. *scotti* Früchtl (= *P. pygmæus* T. Scott, non Claus) in the Gaboon River and Congo River estuaries in the Gulf of Guinea. Here again the only possible explanation appears to be that of dispersal of the ancestral form by the agency of marine currents, followed by evolution into forms or races in certain localities as a result of differences in the local conditions ; and if one accepts the theory of the permanence of the ocean basins, one stage of the journey that may have taken several generations to accomplish must have been across the whole width of the South Atlantic Ocean.

A study of those species that are usually classed as oceanic and benthic reveals that these must be divided into two quite distinct groups. Schott (1935, p. 331) has called attention to the fact that there is a marked and progressive falling off in the total number of planktonic organisms as one passes from the surface down to the greatest depths, and I reproduce below the table that he gives for the Atlantic Ocean :

Depth in m.	Number of individuals per litre.
0	10,147
50	9,443
100	2,749
200	726
400	216
700	114
1000	87
2000	57
3000	18
4000	17
5000	15

Schott maintains that conditions are very similar in all three oceans, and that such local differences as do occur are of comparatively small importance. In the case of the pelagic Copepoda, however, the results obtained by a number of expeditions seems to indicate clearly that this gradual fall in the number of either individuals or species is conspicuous

by its absence. In the results obtained by the " John Murray " Expedition the approximate numbers of individuals of the Copepoda at different depths are as follows :

Depth in metres.	Number of individuals captured.
100–0	>6503*
200–100	601
300–200	220
400–300	728
500–400	1423
600–500	5643
1000–850	3103
1500	341
2000	24
2800	2

These results can only be regarded as approximate since the greater number of hauls were not made with a self-closing net and in consequence the net was fishing all the way from its greatest depth to the surface ; but as in nearly all the hauls the net was towed, so far as could possibly be managed, horizontally for an hour and was then hauled to the surface, it is justifiable to assume that the greater part of the catch was made at the depth of the horizontal part of the haul, and I have taken the figures of each catch as representing the number of individuals present at that depth. Clearly there are two very distinct maxima in the density of the population, one at or near the surface between 100 and 0 m., and a second at a depth of about 600 m., with an intervening minimum at 300–200 m. depth.

Similarly, if we consider the number of species represented in the various catches we reach the same conclusion. In the upper levels at or near the surface the " John Murray " Expedition captured 109 species of epi-planktonic forms. Although it is not possible to give with any degree of certainty the lower limit of occurrence of any of the deep-sea species, since we were only very rarely able to use a self-closing net, it is possible to give the depth below the surface at which, apart from stray individuals, each species first makes its appearance.

At 100 m. depth 9 species were taken, namely :

Calanoides patagoniensis Brady (juv.).
Eucalanus attenuatus (Dana).
E. pseudattenuatus sp. nov.
Rhincalanus nasutus Giesbr.
Undeuchæta bispinosa Esterly (juv.).
Euchirella galeata Giesbr. (juv.).
E. bella Giesbr.
Scottocalanus dauglishi Sewell.
Pleuromamma quadrungulata Wolfend.

* In the case of several of the more common species the numbers present were not actually counted, and they were merely classed as " numerous.

At 200 m. 9 other species have been taken, namely :

Eucalanus elongatus (Dana).
Euchirella orientalis Sewell.
E. pulchra (Lubb.).
Euchæta tenuis Esterly.
Heterorhabdus spinifrons (Claus).
Pleuromamma abdominalis (Lubb.) (juv.).
P. xiphias Giesbr.
Euaugaptilus nodifrons Sars.
Arietellus giesbrechti Sars.

At 300 m. we get 7 other species, namely :

Gætanus miles Giesbrecht.
G. latifrons Sars.
Chirundina indica Sewell.
C. streetsi Giesbr. (juv.).
Pseudochirella magna (Wolfenden) (juv.).
Undeuchæta bispinosa Esterly (adult).
Scottocalanus helenæ (Lubb.).

At 400 m. 11 species were taken for the first time :

Gætanus pileatus Farran.
Euchirella galeata Giesbr. (adult).
E. truncata Esterly.
Paraeuchæta investigatoris Sewell.
P. weberi A. Scott.
Scottocalanus securifrons (T. Scott).
Scaphocalanus magnus (T. Scott).
Heterorhabdus abyssalis (Giesbr.).
Metridia princeps Giesbr.
Pleuromamma indica Wolfend.
P. abdominalis (Lubb.) (adult).

At 500 m. depth 14 more species have made their appearance :

Neocalanus gracilis (Dana).
N. robustior (Giesbr.).
Paræuchæta scotti (Farran).
Megacalanus princeps Wolfend.
Scottocalanus persecans (Giesbr.).
Lophothrix frontalis Giesbr.
Heterostylites longicornis (Giesbr.).
Haloptilus chierchiæ Giesbr.
H. mucronatus (Claus).
H. ornatus (Giesbr.).
H. oxycephalus (Giesbr.).

Lucicutia magna Wolfend.
Augaptilus longicaudatus (Claus).
Copilia hendorfii M. Dahl.

At 650–600 m. we get the appearance of 16 more species :

Bradycalanus sp. (juv.).
Gætanus kruppi Giesbr.
Euchirella maxima Wolfend.
Paraeuchæta sarsi Farran.
P. tonsa (Giesbr.).
Onchocalanus trigoniceps Sars (juv.).
Amallothrix indica Sewell.
Lucicutia challengeri Sewell.
Mesorhabdus angustus Sars.
Disseta palumboi Giesbr.
Euaugaptilus magnus (Wolfend.).
Haloptilus acutifrons (Giesbr.).
H. validus Sars.
Heteroptilus acutilobus Sars.
Arietellus simplex Sars.
A. plumifer Sars.

And with this group we may include *Pseudochirella magna* (Wolfend.) (adult) that was captured in a haul from 645–400 m. At 850 m. depth we get as many as 23 species making their first appearance, namely :

Gætanus brevicornis Esterly.
G. minor Farran.
Euchæta spinosa Giesbr.
Paraeuchæta malayensis Sewell.
P. spinifera Esterly.
Onchocalanus affinis With.
O. trigoniceps Sars.
Xanthocalanus greeni Farran.
Lophothrix quadrispinosa Wolfenden.
Amallothrix arcuata Sars.
A. emarginata (Farran).
A. gracilis Sars.
Gaussia princeps (T. Scott).
Euaugaptilus elongatus Sars.
E. facilis (Farran).
E. indicus Sewell.
E. laticeps Sars.
E. latifrons Sars.
E. longicirrhus Sars.
E. longimanus Sars.
E. oblongus Sars.
Hemirhabdus truncatus (A. Scott).
Pachyptilus eurygnathus Sars.

And with this group we may include *Centraugaptilus horridus* (Farran) that was first taken at 1000 m. depth.

At 1500 m. depth we again get 24 fresh species :

? *Bathycalanus bradyi* (Wolfend.) (juv.).
Calanus finmarchicus Gunn.
Gætanus curvicornis Sars.
G. antarcticus Wolfend.
Euchirella venusta Giesbr.
Pseudochirella notacantha Sars.
P. obtusa Sars.
Undeuchæta major Giesbr.
Pseudeuchæta brevicauda Sars.
Paraeuchæta bisinuata Sars.
P. withi sp. nov.
Valdiviella oligarthra Steuer.
Lophothrix humilifrons Sars.
Hemirhabdus grimaldii (Richard).
Lucicutia bicornuta Wolfend.
Euaugaptilus angustus Sars.
E. bullifer (Giesbr.).
E. digitatus Sars.
E. grandicornis Sars.
E. penicillatus Sars.
E. tenuispinus Sars.
Pachyptilus lobatus Sars.
Phyllopus impar Farran.
P. muticus Sars.

Below this depth we get an extremely rapid reduction in the number of species that make their first appearance. At 2000 m. depth we get only two, namely :

Paraeuchæta hanseni (With).
Valdiviella insignis Farran.

At 2500 m. depth we get only one fresh species making its first appearance, namely :

Bathycalanus bradyi (Wolfend.) (adult).

And finally at 2926 m. depth we again get only one :

Bradycalanus gigas sp. nov.

If now we arrange these numbers in tabular form, as follows :

Depth in metres.	Number of species first taken at this depth.
0	109
100	9
200	9
300	7
400	11
500	14
600–650	16
850–1000	24
1500	24
2000	2
2500	1
2926	1

it seems clear that with increasing depth there is a gradual increase in the number of deep-sea species and that the maximum in this region of the Indian Ocean is to be found at about 850–1500 m., and that below this there is a very rapid reduction in the number. It will also be noted that in several species young forms have been taken at a considerably higher level than the adults.

An analysis of the catches obtained by previous expeditions yields very similar results. In the collections made by the " Investigator " in the Bay of Bengal and Laccadive Sea (*vide* Sewell, 1929 and 1932) 138 warm-water epi-planktonic species were obtained: in the deeper levels at 366 m. (200 fms.) 45 deep water species were taken; at about 732 m. (400 fms.) 21 of these species had disappeared but 30 others had made their first appearance, thus making a total of 54 species in all at this depth; and at 1280 m. (700 fms.) 38 of these 54 had disappeared but 54 others had taken their place, so that the total number of species recorded from this depth was 70. As in the " John Murray " Expedition, the nets were towed for about an hour at or near the given depth and were then hauled to the surface fishing all the way up, but it is assumed that the greater number of each species in these hauls came from the depth given. Damas and Koefoed (1907) have given the following results for the area between Spitzbergen and Greenland in about lat. 75° N.:

Depth in metres.	Number of species present.
0–20	6
20–100	11
100–200	13
200–500	15
500–1000	17
Over 1000	21

Wolfenden (1904) has given tables of the numbers of species obtained by him in the North Atlantic Ocean and the Faroe-Shetland channel in different degrees of latitude between 50° and 61° N., and if we take the average of all the data we get the following result:

Depth in metres.	Number of species captured.
0	5
183	9
366	10
549	16
732	12
914	12
1097	8
1280	8
1463	8
1829	7
2195	9

and Wolfenden remarks that "it is not unfair to conclude from these data that the greater number of species of Copepoda in the North Atlantic prefer a mesoplanktonic existence between 200–500 or 600 fathoms (366–914 or 1097 m.) depth"; the greatest number are apparently to be found at about 550 m. Thompson (1903) at three stations in deep water to the west of Ireland has given the following figures:

Depth in metres.	Number of species present. Lat.: 52° 27·5′ N. Long.: 15° 40′ W.	52° 18′ N. 15° 53′ W.	52° 20′ N. 15° 7·9′ W.
0	6	5	..
100–200	..	..	4
200–300	..	..	8
300–400	..	..	8
400–500	..	..	2
500–600	..	16	17
600–700	..	..	11
700–800	5	19	..
900–1000	10	21	..
1000–1100	17	32	..
1100–1200	20	21	..
1300–1400	12	19	..
1400–1500	16	24	..
1500–1600	22	25	..
1600–1700	24	20	..
1700–1800	6	14	..

It seems probable that in this region there are two maxima at different depths, the first occurring at about 1000–1200 m. depth and the second at 1500–1700 m. depth. It seems possible that this double maximum is associated with the presence of more than one layer of water; Wüst (1936) gives a figure showing the depth distribution of the various water masses that compose the Atlantic Intermediate water, and in these northern latitudes we seem to have the "North Atlantic upper deep water" at about 1000 m. depth, and in continuity with this is the outflowing Mediterranean water; immediately below this lies

the "North Atlantic middle deep water." Farran (1926) has given the results obtained by the "Research" in the Bay of Biscay; in this collection a series of vertical hauls were made with self-closing nets, and Farran has made a careful analysis of the numbers of species and the average number of specimens taken at the different levels, which I reproduce below:

Depth in metres.	Depth in fathoms.	Number of hauls.	Total number of species.	Average number of specimens per 100 fms. (183 m.).
274–91	150–50	1	20	515
274–183	150–100	1	17	164
366–183	200–100	6	47	425
457–274	250–150	3	43	781
549–366	300–200	3	44	522
732–549	400–300	3	50	373
914–732	500–400	3	57	296
1372–914	750–500	4	66	232
1820–1372	1000–750	3	65	245
2286–1829	1250–1000	2	22	78
2743–2286	1500–1250	1	14	88
3658–2743	2000–1500	1	11	4·6

In this series the greatest number of specimens occurs at a depth of 274–91 m. or at 457–274 m., with an intervening minimum at 274–183 m.; but the greatest number of species occurs at a depth of about 1372 m. T. Scott (1894) in a series of tow nettings at different depths in the Gulf of Guinea in lat. 1° 55′ 5″ N., long. 5° 55′ 5″ E. obtained the following results:

Depth in metres.	Number of species captured.
0	21
55	44
110	15
293	19
476	26
658	47
841	28

In the collections made by the "Siboga" in the Malay Archipelago (*vide* A. Scott, 1909) an analysis of the various catches indicates that about 150 warm-water epi-planktonic species were taken, and in the deeper levels the number of species captured in the various hauls are as follows:

Depth in metres.	Number of deep-sea species taken.
200–0	8
750–0	69
900–0	43
1000–0	80
1500–0	79
2000–0	39

In this region we thus appear to have two maxima, the upper at a depth of about 750 m. and a second at about 1000 m., and it is interesting to note that in the upper group at 700–750 m. depth there are 13 species that do not occur at the lower level, while in the lower group at 1000–2000 m. depth there are as many as 55 species that were not taken in the upper strata, which strongly suggests that we are here dealing with two different masses of water. A somewhat similar condition was found in the North Atlantic Ocean by Leavitt (1938) in the western region. Leavitt attributes this phenomenon to the different conditions existing in two superposed water masses of different origin. If we consider the number of species taken at different depths in the various basins of the Malay Archipelago we get the following results :

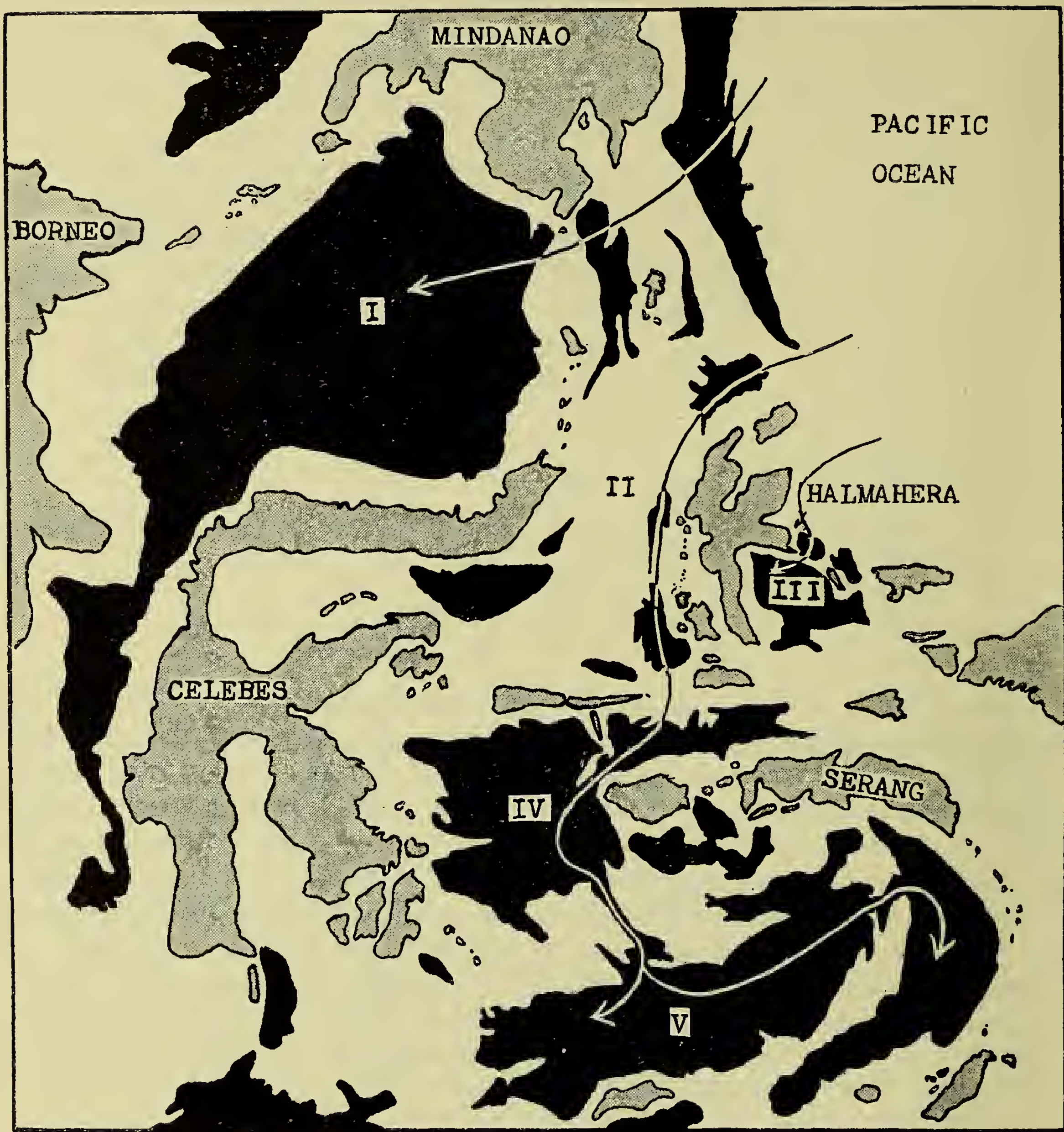
Depth in metres.	Celebes Sea.	Halmahera Basin.	Molucca Passage.	Total.	Banda Basin.
200–0	..	..	..	..	8
475–415	..	..	..	..	7
700–0	38	..	..	38	..
750–0	..	..	..	..	59
900–0	43	..	..	43	..
1000–0	..	72	..	72	34
1500–0	..	..	65	65	61
2000–0	..	..	..	..	38

It thus appears that in the region of the Celebes Sea, Halmahera Basin and the Molucca Passage there is a single maximum situated at a depth of about 1000 m., but in the Banda Basin there seems to be two maxima at about 750 and 1500 m. respectively. van Riel (1938) has shown that the deep water of the Celebes and Halmahera Basins (Text-fig. 72) enters directly from the Pacific Ocean, whereas the inflowing water in the Banda Basin has passed successively through, first, the Morotai Basin and the Ternate Trough, and then on from the Batjan Basin through the Boeroe Basin into the Banda Basin, and that this deep water enters the Banda Basin at a depth of about 1500 m. : he has given a diagram to illustrate this (van Riel, 1938, Pl. II), though he specifically warns the reader that the arrows in the diagram, which I reproduce below (Text-fig. 73), must not be interpreted as stream lines. It thus appears probable that the lower maximum in the Banda Basin is correlated with this inflowing deep water.

The report by Vervoort (1946) on the Copepoda of the "Snellius" Expedition in the eastern part of the Netherlands East Indies gives a similar result :

Depth of haul.	Number of species taken.
200–0	4
500–0	9
1000–0	12
1500–0, 2000–0	9
2500–0	8
3000–0, 4000–0	5

In this collection the maximum number of species was taken at a depth of about 1000 m.



Text-fig. 72.—Sketch Map showing the deep basins of the Malay Archipelago. I. Celebes Sea. II. Molucca Passage. III. Halmahera Basin. IV. North Banda Basin. V. South Banda Basin.

Again, an analysis of the results obtained by the " Terra Nova " (*vide* Farran, 1929) shows that in the New Zealand area of the Pacific Ocean 69 species belonging to the warm-water surface-living group were taken, but that as we pass further southwards the number of these rapidly falls off, and in latitudes higher than 60° S. the number of cool-water, deep-dwelling forms shows a marked tendency to occur on or near the surface. Thus in lats. 30°–40° S. to the north of New Zealand, while still in the sub-tropical region, the " Terra Nova " captured at or near the surface as many as 117 species, but of these 69 were warm-water epi-planktonic forms, the remaining 48 being such as are usually

taken in the tropics in greater depths. Still further south, in lats. 50°–60° S., within the region of the West Wind Drift, 40 species were taken in the upper 40 m., but of these only 12 were warm-water, epi-planktonic forms and 28 were cool-water, deep-dwelling species that occur in the lower strata in the tropical region. In the true Antarctic region, south of lat. 60° S., only 5 warm-water epi-planktonic species were captured ; here the numbers of species that were taken at the different levels were as follows :

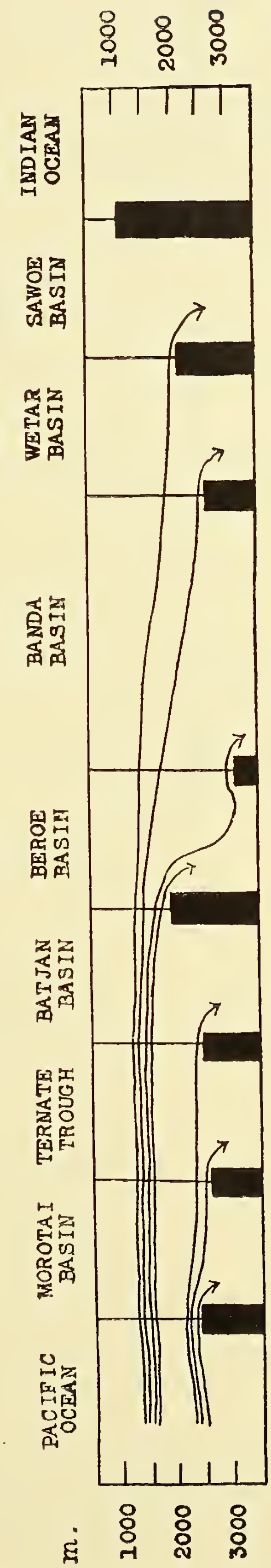
Depth in metres.	Number of species captured.
100–0	30
150–120	6
200–150	4
300	3
450–400	7 (? 8)
500	7
600	11
1000	31
1750	20

Here again we get a clear indication of two maxima in the number of species present, namely, at 100–0 m. and 1000 m. respectively.

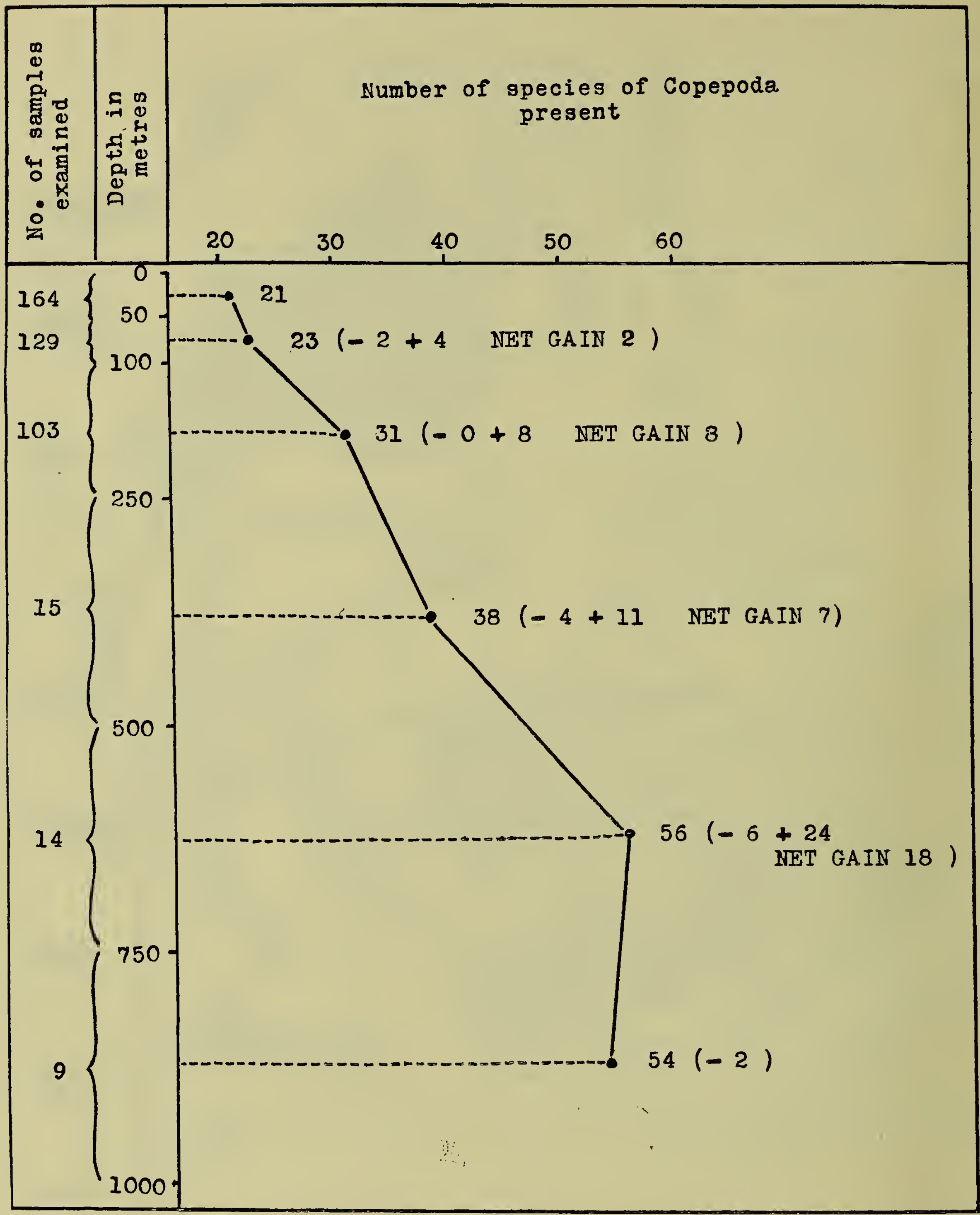
In the "Discovery" collections from the Antarctic (*vide* Hardy and Gunther, 1935) there appears to be a steady increase in the total number of species present as we pass downwards from the surface, the maximum being reached at about 600–700 m. I reproduce overleaf the curve, drawn by Mr. Andrew Scott, that these authors have published of the number of species of Copepoda taken at different depths (Text-fig. 74).

A very similar result was obtained by the "Gauss" in the Indian Region of the Antarctic Ocean (*vide* Wolfenden, 1911). In this collection the number of species taken at different depths was as follows :

Depth in metres.	Number of species taken.	Tropical species.	Antarctic species.
100	4	1	3
150	12	2	10
350–400	25	10	15
1200	35	14	21
2000	26	10	16
3000	25	10	15
3423	11	3	8



TEXT-FIG. 73.—Indicating the direction of flow of the bottom water from the Pacific Ocean into the various basins of the Malay Archipelago. (From P. M. van Riel, 1938.)



Text-fig. 74.—Curve showing the increasing number of species of Copepoda with increasing depth in the South Georgia region of the Antarctic zone. (From Hardy and Gunther.)

In this area the greatest number of species occurs at a depth of about 1200 m. As Hardy and Gunther (1935, p. 121) have pointed out, " it would appear that only a limited number of species have been able to adapt themselves to the conditions of the cold Antarctic surface layer " ; and, furthermore, it seems equally true that the maximum

number of so-called Antarctic species is to be found at the same depth and in the same water mass as that in which occurs the main influx of tropical species into the Antarctic region.

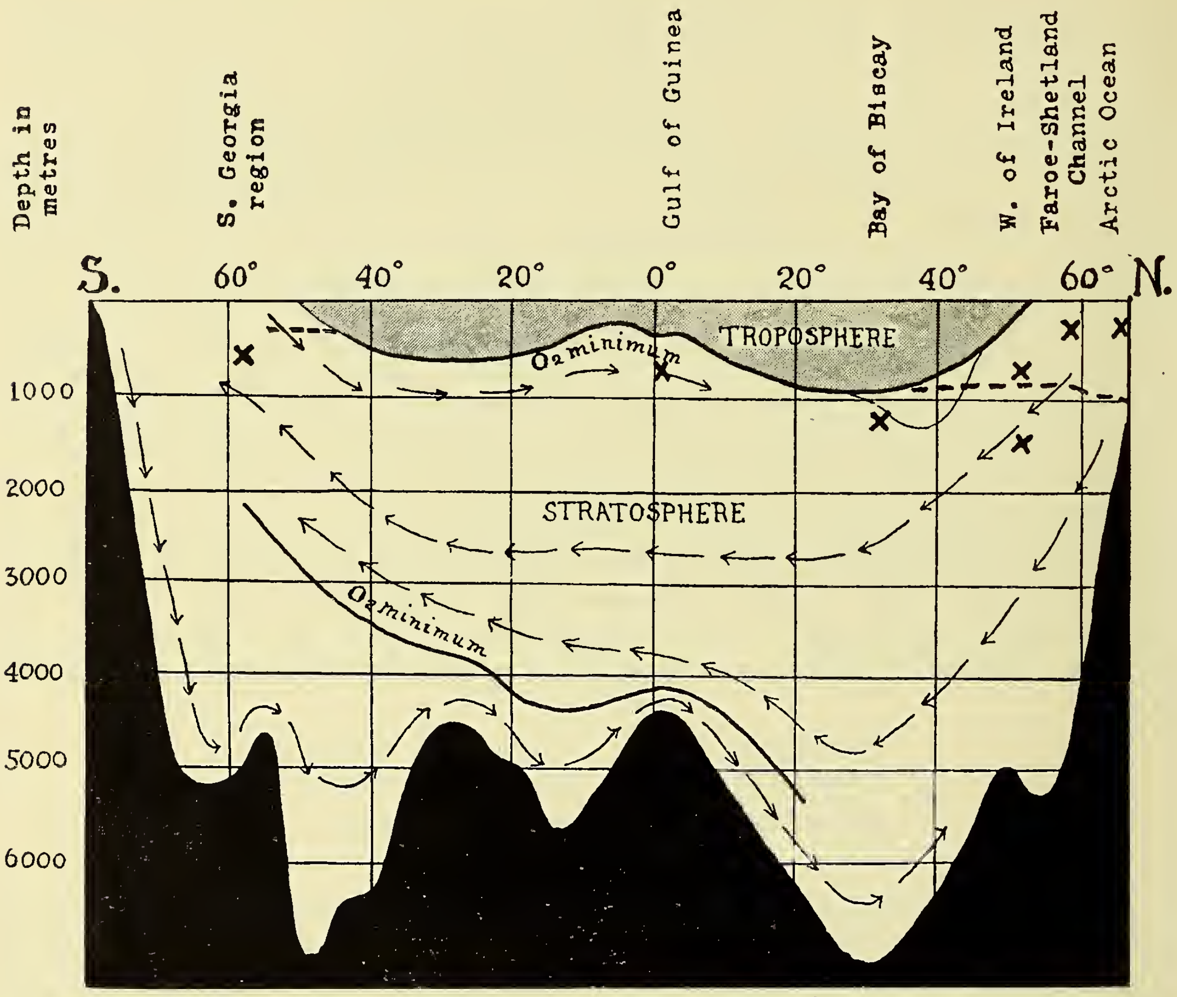
The available evidence thus points to the conclusion that the planktonic Copepoda as a whole can be divided into two main groups, (1) those that inhabit the warm upper stratum of the tropical and sub-tropical regions, for the most part in the 100–0 m. stratum, and (2) those that inhabit the cool, deep-water stratum and have an optimum at a depth that may vary in different regions, but falls between 550 and 1200 m. depth ; but no hard and fast line can be drawn between these two groups, for some species that are normally to be found in the upper warm layer may be carried down into deeper levels and thus be taken with the cold-water, deep-dwelling forms, and, conversely, some of the deep species may be brought by upwelling currents to, or near to, the surface, and thus be taken alongside the warm-water forms, while representatives of both groups may be carried into the cold water of the surface layer in the Arctic and Antarctic regions. F. Dahl (1894*a*) put forward the view that the pelagic Copepoda could be divided into three groups, namely, an upper group that inhabits the stratum from the surface down to 100–200 m., a middle group inhabiting depths between 200 and 1000 m., and lastly, a deep group living below 1000 m. depth. Defant, in a paper published in 1928, divided the oceans into three strata, namely an upper warm-water layer that is found only in the tropical and sub-tropical regions, and to which he gave the name "Troposphäre" and the uppermost layer of which he designated the "Störungzone," and a deeper cold-water layer, the "Stratosphäre," that includes the deep water of the ocean basins and the water of the two Polar regions. He gave the approximate depths of these layers, as follows :

"Störungzone,"	from	0	to about	200 m.
Troposphere,	,,	200	,, ,,	1300 m.
Stratosphere,	,,	1300	,,	the bottom.

One might thus be tempted to correlate each of Dahl's groups with one of the three strata into which Defant has divided the ocean : thus Dahl's first group might be regarded as inhabitants of the "Störungzone," the middle group of the deeper layer of the Troposphere and, lastly, the third, deep-dwelling group as belonging to the Stratosphere. But the above results do not bear this out, and although certain species are to be found for the most part, if not exclusively, in the deepest levels, these cannot be separated off as a distinct group. In a later paper, however, Defant (1930) puts the thickness of the upper stratum, including both the "Störungzone" and the rest of the Troposphere, as not greater than 400–500 m. Wüst (1936) claims that between lat. 45° S. and lat. 53° N. in the North Atlantic Ocean lies a layer of warm water, namely the Troposphere, having an average depth of about 500 m., and, if we accept this estimate, then the two groups of the oceanic Copepoda will coincide respectively with the Troposphere and the Stratosphere.

Wüst further suggests that the boundary between the Troposphere and the Stratosphere below it "is best characterized by the intermediary principle minimum of oxygen, which may be traced from 45° S. to 55° N., and which for the most part coincides approximately with the isotherm of 8° C." Although the depth at which we find the maximum number of deep-sea species in the Copepoda varies somewhat in different regions, in every

case it falls between 550 and 1200 m., and a comparison of these depths with the depth of the minimum oxygen concentration shows a very considerable degree of agreement. In the two figures given below I have plotted the position of the maximum concentration of the Copepoda on the chart of minimum oxygen in the Atlantic (Text-fig. 75) and the

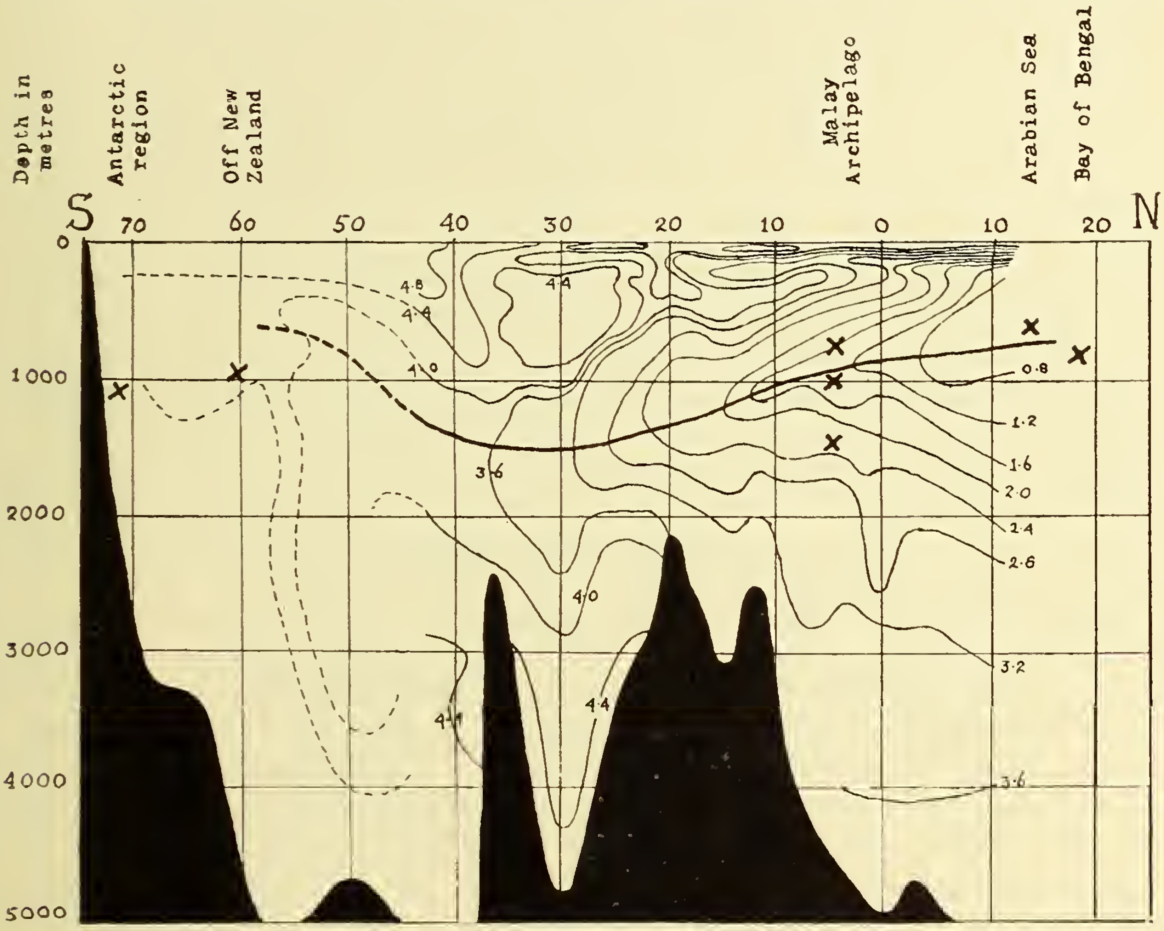


TEXT-FIG. 75.—A Section of the Atlantic Ocean showing the depth of the O_2 minimum layers (after Defant, 1936, and Wüst, 1936) and the position of the maximum concentration of species in different regions.

Indian (Text-fig. 76) Oceans, and on this latter I have also given the maximum concentration of the Copepoda in the Malay Archipelago. Seiwell (1937, p. 19) has pointed out that " from general oceanographic knowledge it seems probable that the biological activity of the water mass plays an important role in fixing the minimum oxygen concentration at mid depths. This may be brought about either by a maximum concentration of oxidizable organic matter at the depth of the oxygen minimum concentration, or (if the supply of oxygen by horizontal currents varies with depth) by vertical variations of biological activity causing the ratio O_2 utilized/O_2 supplied to be continuously increased as the depth of the minimum oxygen concentration is approached both from above and below." The concentration of the Copepod fauna, in both the number of species and individuals present, at or near the depth of the minimum oxygen concentration is in keeping with the

view expressed by Seiwell that biological activity plays an important part in causing this minimum.

One of the most important factors in the distribution of species is the temperature of the water in which they are living, and especially of the range of temperature from season to season or from one point in a current system to another. Rose (1925, p. 518) has put forward the view that, if there be any marked difference in either temperature



TEXT-FIG. 76.—A Section of the Indian Ocean showing the O_2 concentration at different depths (after Clowes and Deacon, 1935) and the position of the maximum concentration of species in different regions in the Indian and West Pacific areas.

or salinity between the current and its surrounding water, such a current will serve as a barrier to the horizontal propagation of species, as suggested by Chun, but will also tend to retain its own peculiar fauna until, as one follows the current along, the difference between it and the surrounding water gradually lessens, and a stage is eventually reached where the indigenous fauna of the current can pass out of its limits into the surrounding ocean, or, *vice versa*, species characteristic of the surrounding ocean can pass into the current until finally the individual peculiarities of the fauna within and outside the stream disappear and the fauna becomes homogeneous. Störmer (1933) has pointed out that in a single current system, such as the Gulf Stream and its continuation the North Atlantic Drift, the pelagic life is in its origin tropical, but that very few of the different species manage to enter the North Sea and succeed in breeding there ; the water of a current

such as this appears to be characterized by a steadily increasing deficiency of certain species, and furthermore, the extreme limit to which any given species can be carried and still survive will vary from season to season and from year to year with changes in the hydrographical conditions, and especially in the temperature, the more resistant species being carried farther northward than the less resistant forms. In this great current system there is at its origin an average annual temperature of about 27° C., with a range of about 5·5° C., whereas as we follow its course across the Atlantic Ocean and on past the north coast of Norway the temperature falls to 0° C., or even less, in the Arctic region. For each species there is a definite temperature range within which the species can continue to live, but there is a much smaller range within which it can reproduce, and a still smaller one within which the species can be at its optimum. As each species passes out of the temperature range within which it can reproduce, its final disappearance becomes a certainty, the actual place depending on the length of life of the individual and the rate of the current. Pfeffer (1903) states that "it is easy to understand that, owing to the depressant effect of low temperatures upon metabolism, they should take longer to produce a fatal effect than high ones, which steadily accelerate respiration." He was referring to the effects of temperature on plant life, but the same must equally apply to animals; and Edmondson (1928, p. 26) remarks "that living organisms are more capable of enduring a gradual reduction of temperature than a gradual increase of temperature is well known." Many species, and even genera, tend to be limited to a particular current system, or set of systems, as has been clearly demonstrated in the case of the genus *Copilia* by Lehnhofer (1926); and the number of species that can survive a transfer from one system to another will depend on the hardiness of the individual and the extent of the change in physical conditions, especially that of temperature, which such a transfer entails, and the suddenness with which this change is brought about. The boundaries between such current systems in the surface waters, where these changes are most marked, are the Sub-tropical and Sub-polar convergence zones, and it is especially along these lines that we find the main barriers to the passage of epi-planktonic species either from warm to cool or cold water in the case of species that have originated in the tropical and temperate regions or from cold or cool water to warm for species that have evolved in northern or southern latitudes. That the passage from cold to warm water is much more effective as a barrier to the transfer of Copepoda than a change in the opposite direction is clearly indicated.

Wolfenden (1908 and 1911) has shown that in the Indian Ocean immediately to the north of New Amsterdam Island there is a radical change in the character of the Calanoid fauna and that, similarly, in the Atlantic Ocean true Antarctic species are to be found only as far north as lat. 40° S., but that a few typical Atlantic deep-water species can penetrate into the Antarctic; I have shown (Sewell, 1940*a*, p. 361) that the same holds good for the weed-haunting Harpacticids. Among the planktonic Copepoda some 43 species of warm-water, epi-planktonic Calanoids from the Indo-Pacific region have been able to extend their range southwards into the cool water of the West Wind Drift, and 20 have actually got as far as the cold Antarctic region (*vide infra*, p. 453), whereas not a single species that has been evolved in the southern cold region has been able, so far as I know, to pass northwards across the convergence zones and so become an ingredient of the epi-planktonic fauna of the warm-water regions, though they may be carried northwards in the deeper cold currents. This division into warm-water and cold-water faunas

is not a hard and fast one, and the boundary between the various faunas may vary from season to season and year to year. Mackintosh (1934) in his review of the distribution of the Antarctic Macro-plankton has shown that "the evidence leaves no reasonable doubt (1) that in the South Georgia plankton the cold-water species are most strongly represented in the spring, and that as the summer advances they are reduced and the warm-water species gain ground, and that the warm-water plankton continues right through the winter: (2) that an abnormally cold summer results in a 'colder' plankton which, however, still becomes 'warmer' as the summer passes." It is generally recognized that one of the chief factors in regulating the distribution of the Copepoda is the temperature of the water. A great deal of work will be necessary before we can hope to have an adequate knowledge of the temperature range of all the various species, but already it is evident that this range differs widely in different species, even in those of the same genus. Ruud (1929) gives the range for *Calanus finmarchicus* (Gunn.) as extending from 2·0° C. to 22·0° C., whereas in *Calanus hyperboreus* Kröyer it is only from 5·0° C. to 7·5° C. Steuer (1931*a*) in the genus *Rhincalanus* gives for *R. cornutus* (Dana) a range from 3·5° C. to 27·5° C. for the f. *typica** and from 4·5° C. to 17·5° C. for the f. *atlantica*; for *R. nasutus* Giesbr. he gives a range of − 0·5° C. to 15·5° C., and for the same species Schmaus and Lehnhofer (1927) give ranges of from 3·0° C. to 20·0° C. in the Indian Ocean and from 3·0° C. to 15·0° C. in the Atlantic. For *R. gigas* Brady, Steuer (*loc. cit.*) gives a range from − 2·0° C. to 7·5° C. Among other species that appear to possess a moderate or wide temperature range the following may be mentioned:

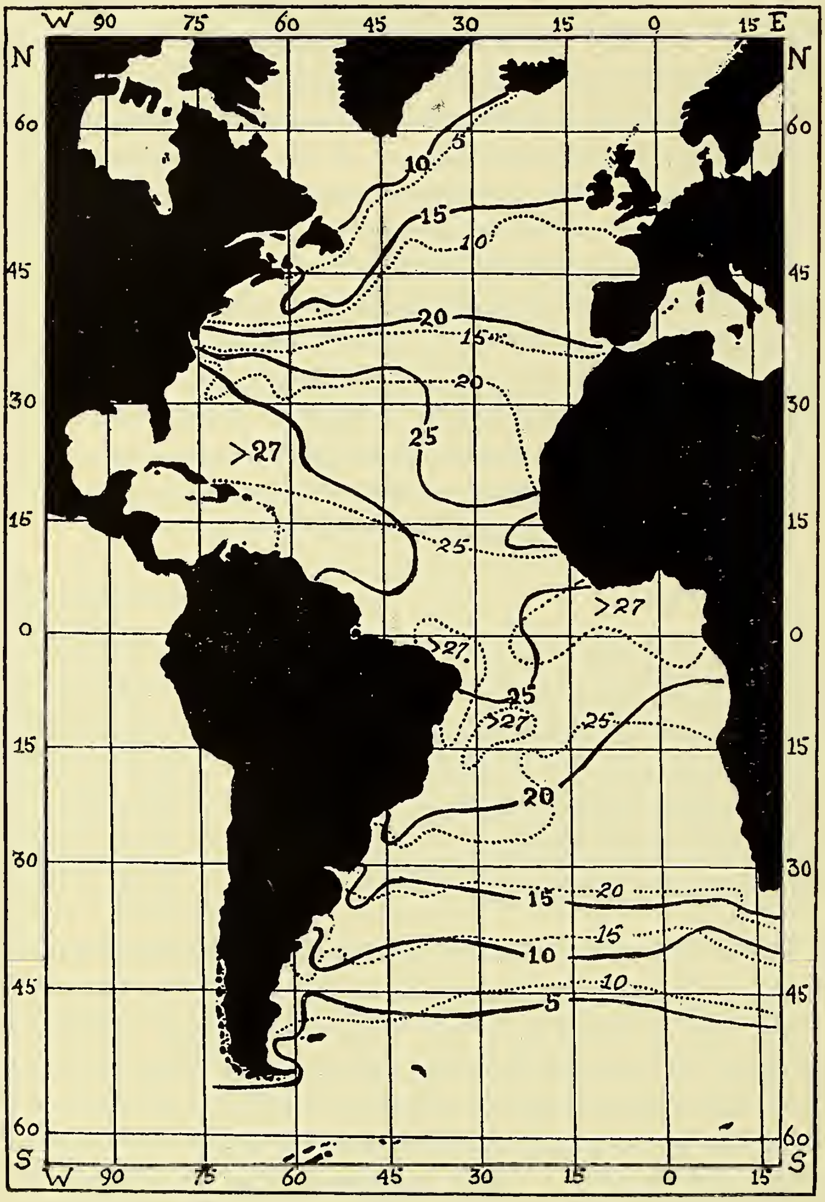
Species.	Temperature range. (° C.)
Paracalanus parvus (Claus)	− 1·23 to 28·0
Scolecithricella minor Brady	− 1·23 ,, 28·0 ?
Pseudocalanus elongatus (Boeck)	− 1·23 ,, 13·0
Temora longicornis (O. F. Müll.)	5·0 ,, 25·0 ?
Scolecithricella ovata Farran	2·9 ,, 10·0
Euchirella rostrata (Claus)	2·9 ,, 13·5
Metridia lucens Boeck	4·83 ,, 16·1

The upper limit in the case of the 2nd and 4th species in the above list is open to some doubt, and depends, as all such records must do, on the correct identification of the species.

Ability to exist and to breed in a wide temperature range will enable a species to survive transportation by currents for long distances, and thus to extend its habitat horizontally in the surface layer from the tropics to temperate or even cool regions, and in extreme cases to Arctic or Antarctic latitudes, and vertically from the surface down to considerable depths. Ekman (1935, p. 93) emphasizes that the temperature of the water is one of the most important factors in determining the distribution of the marine fauna; he follows Ortmann (1896) in taking the annual mean isotherm of 20° C. in the surface water as forming the boundary between the tropical and the northern and southern faunas, and he claims that this is in agreement with the conditions found in various regions, such as South Africa, Japan, Australia, and North and South America. As regards the first of these localities Stephenson (1944) remarks, "It would therefore appear that the most

* In a later work, Steuer (1937, p. 138) records the presence of a female and a young male in the South Atlantic at a depth of 700 m. and in a temperature of 2·6° C.

rapid disappearance of animal species takes place as soon as the mean annual temperature falls distinctly below 20° C.," and he adds, "this agrees rather well with Vaughan's statement that 'it seems that a continuous bottom temperature of about 21° C. is the lowest at which reef-forming corals may be expected to live'." Fritsch (1945), in an article on *Ceratium* and Marine Hydrography, defines the tropical species as those which are in-



Text-fig. 77.—Showing the isotherms of the surface-water in the Atlantic Ocean in the months of February and August. (From Harvey, 1945.)

tolerant of cold water and are fairly closely confined to water having a temperature of 19° C. and over; but he points out that the Gulf Stream carries *Ceratium extensum* to the British Isles, where the temperature is 12·4° C., and *C. hexacanthum* to Iceland, where the surface temperature is as low as 8·9° C., though in other areas these two species are not found below 14·9° C. and 18·9° C. respectively. While a temperature of 20° C. may be

critical for littoral-haunting animals, it seems to me that it is rather too high for the epi-planktonic Copepod fauna, and that the limiting temperature falls nearer to 15° C. So far as the genus *Sapphirina* is concerned nearly every recorded catch falls within the limits of this annual mean isotherm (*vide* Text-fig. 83), the only exceptions being a few scattered records in the Antarctic and along the north Atlantic Drift. During the course of the year the position of the 15° C. isotherm in the North Atlantic changes its position (Text-fig. 77): in the month of August the maximum temperature of the surface water in the tropical region lies off the west African coast, in about lat. 15° N., and the 15° C. isotherm strikes the British Isles in about 53° N., whereas in February the highest temperatures are found on the African coast in the Gulf of Guinea at about the level of the equator, and the 15° C. isotherm strikes the entrance to the Strait of Gibraltar. A study of the distribution of the warm-water epi-planktonic species shows that a number of these, which are normal inhabitants of the warm surface waters of the Indo-Pacific and Atlantic tropical regions in temperatures of over 25° C., are still found in the North Atlantic as far north as lat. 40°–50° N. On the American side in the region of Woods Hole and Cape Cod, in lat. 40°–42° N., these Indo-Pacific species form 68 per cent. of the total number of epi-planktonic species that have been recorded, while on the European side off the south-west corner of Ireland, in lat. 52°–54° N., they still form 53 per cent. A reference to Text-fig. 77 shows that these regions correspond closely with the isotherm of 15° C. of the surface water during the month of August. Similarly, in the southern Hemisphere Wolfenden, as already mentioned, has suggested that the line of lat. 40° S. marks the boundary between the warm-water and the true Antarctic species, and a reference to Text-fig. 77 shows that this corresponds in the South Atlantic Ocean reasonably closely with the isotherm of 15° C. in the month of February.

Farran (1926) has given tables showing the depth distribution of certain species that were taken in the Bay of Biscay, and in these one notes the presence in very considerable depths of species that are normally to be found in the surface layer:

Species.		Depth in metres.	
Aegisthus mucronatus Giesbr.	down to	1372	(750 fms.).
Eucalanus crassus Giesbr.	,,	1372	,,
Scolecithricella dentata Giesbr.	,,	1372	,,
Paracalanus parvus (Claus)	,,	1830	(1000 fms.).
Euchaeta acuta Giesbr.	,,	1830	,,
Centropages typicus Kröyer	,,	1830	,,
Oithona atlantica Farran	,,	1830	,,
Oithona similis Claus	,,	1830	,,
Ctenocalanus vanus Giesbr.	,,	2286	(1250 fms.).
Clausocalanus pergens Farran	,,	2743	(1500 fms.).
Acartia clausi Giesbr.	,,	2743	,,
Pseudocalanus elongatus (Boeck)	,,	3000	(1700 fms.).
Clausocalanus arcuicornis (Dana)	,,	3658	(2000 fms.).

Wolfenden (1904) has recorded the presence of *Anomalocera patersoni* Templ. at a depth of 750 m. in the North Atlantic and *Ectinosoma atlanticum* Brady (=*Microsetella norvegica* (Boeck)) at 2195 m. Ruud (1929) has given data from several authors for *Calanus finmarchicus* (Gunn.), and he shows that whereas the low limit of distribution is usually about

200 m., examples have been taken by Paulsen off Iceland down to 500 m. and by Damas and Koefoed in the northern Norwegian Sea as far down as 1200 m.; Murray and Hjort (1912) have recorded it as deep as 1600–1850 m. Leavitt (1938) has recorded *Euchæta marina* (Presland.) and *Rhincalanus cornutus* (Dana) at a depth of 2400 m., and Wilson (1932, p. 23) records *Nannocalanus minor* (Claus) from a depth of 2743 m. in the Woods Hole region. Another surface-living species that has been recorded from considerable depths is *Microcalanus pygmæus* Sars, down to 1200 m. Wolfenden (1911) has recorded no less than 37 species, that are normally to be found in the surface layer from 0 to 400 m., which were taken by the "Gauss" at a depth of 3000 m. These are:

Eucalanus monachus Giesbr.
E. mucronatus Giesbr.
Rhincalanus cornutus (Dana).
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).
Centropages violaceus (Claus).
Candacia bispinosa Claus.
C. longimana Claus.
C. pachydactyla Dana.
C. varicans Giesbr.
Labidocera acutifrons (Dana).
Oithona linearis Giesbr.
O. plumifera Baird.
O. similis Claus.
Oncæa conifera Giesbr.
O. mediterranea Giesbr.
O. venusta Philippi.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus alatus Giesbr.
C. furcifer Claus.
C. longistylis Dana.
C. ovalis Claus.
C. speciosus Dana.
Corycella gibbula (Giesbr.) (= *pelucidus* Dana).
Saphirina angusta Dana.
S. intestinata Giesbr.
S. metallina Dana.
S. opalina Dana.
S. ovato-lanceolata Dana.
Copilia denticulata Claus.
C. lata Giesbr.
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea Giesbr.
Macrosetella gracilis (Dana).
Ægisthus mucronatus Giesbr.

The positions at which these catches were made all lie between lat. 35° S. and 35° N., and reference to the salinity charts of the Atlantic Ocean given by Wüst (1928, Pl. XXXIII) shows that they correspond to the North Atlantic Intermediate water, that is sinking down in the North Atlantic between lats. 20° and 50° N. There can be little doubt that as this water-mass sinks down and then flows southwards it carries with it numerous species that normally are to be found inhabiting the warm, tropical and subtropical surface layer.

On the other hand certain species that are normally to be found inhabiting the cold deep strata are occasionally taken in the surface layer. We have already seen that these species are probably associated with the "Stratosphere" layer of the ocean, and one would thus expect to find a number of these at or near the surface in the polar regions where the "Troposphere" stops short at the Polar Front and the "Stratosphere" comes to the surface, but their presence in the surface layer in the tropical and subtropical regions must have entailed their passage through or at least into the Troposphere, so as to permit of their presence between 0 and 400 m. depth, or in some instances from 0 to 100 m., while individual specimens are by no means uncommon actually on the surface. I have been able to collate such records of the following species :

Calanus finmarchicus (Gunn.).
C. helgolandicus Claus.
C. hyperboreus Kröyer.
C. tenuicornis Dana.
Calanoides brevicornis (Lubb.).
C. patagoniensis (Brady).
Megacalanus princeps Wolfend.
Bathycalanus princeps (Brady) (= *rigidus* Sars).
Neocalanus gracilis (Dana).
N. robustior (Giesbrecht).
Eucalanus attenuatus (Dana).
E. elongatus (Dana).
Rhincalanus nasutus Giesbr.
Spinocalanus abyssalis Giesbr.
S. caudatus Sars.
S. magnus Wolfend.
S. spinosus Farran.
Euæetideus giesbrechti (Cleve).
Ætideus armatus Brady.
A. bradyi A. Scott.
Pseudætideus armatus (Boeck).
Chiridius gracilis Farran.
C. poppei Geisbrecht.
Chirundina indica Sewell.
C. streetsi Giesbr (juv.).
Undinopsis bradyi Sars.
Gætanus armiger Giesbr.
G. kruppi Giesbr.

G. latifrons Sars.
G. miles Giesbr.
G. minor Farran.
G. pileatus Farran.
Gaidius tenuispinus (Sars).
G. affinis Sars.
G. pungens Esterly.
Euchirella amœna Giesbr.
E. bella Giesbr.
E. brevis Sars.
E. curticauda Giesbr.
E. galeata Giesbr.
E. intermedia With (=*truncata* Esterly).
E. messinensis (Claus).
E. orientalis Sewell.
E. pulchra (Lubb.).
E. rostrata (Claus).
Undeuchæta bispinosa Esterly.
U. major Giesbr.
U. plumosa (Lubb.).
Pseudochirella magna (Wolfend.) (juv.).
P. divaricata. (Sars).
Valdiviella minor Wolfend.
Euchæta hebes Giesbr.
E. spinosa Giesbr.
E. tenuis Esterly.
Paraeuchæta grandiremis (Giesbr.).
P. incisa Sars.
P. investigatoris Sewell.
P. flava (Giesbr.).
P. norvegica Boeck.
P. tonsa (Giesbr.).
P. tumidula Sars.
P. weberi A. Scott.
Phaenna spinifera Claus.
Amallophora typica T. Scott.
Heteramalla dubia (T. Scott).
Onchocalanus cristatus (Wolfend.).
O. nudipes Wilson.
O. trigoniceps Sars.
Scottocalanus dauglishi Sewell.
S. helenæ (Lubb.).
S. securifrons (T. Scott),
Lophothrix latipes (T. Scott).
L. frontalis Giesbr.
L. humilifrons Sars.

Scaphocalanus brevicornis (Sars).
S. curtus (Farran).
S. echinatus (Farran).
S. elongatus A. Scott.
S. medius Sars.
S. magnus (T. Scott).
Scolecithricella abyssalis (Giesbr.).
S. auropecten (Giesbr.).
S. dentata (Giesbr.).
S. marginata (Giesbr.).
S. porrecta (Giesbr.).
S. vittata (Giesbr.).
Amallothrix arcuata Sars.
A. obtusifrons Sars.
A. propinquus Sars.
A. valida Farran.
Temoropia mayumbæensis T. Scott.
Metridia brevicauda Giesbr.
M. curticauda Giesbr.
M. longa Lubb.
M. lucens Boeck.
M. princeps Giesbr.
Pleuromamma abdominalis (Lubb.).
P. gracilis (Claus).
P. indica Wolfend.
P. quadrungulata (Dana).
P. robusta (Dahl).
P. xiphias Giesbr.
Lucicutia bicornuta Wolfend. (= *aurita* Sars).
L. clausi Giesbr.
L. flavicornis (Claus).
L. grandis Wolfend.
L. longicornis Giesbr.
L. ovalis Wolfend.
Heterorhabdus abyssalis (Giesbr.).
H. compactus Sars.
H. norvegicus (Boeck).
H. papilliger (Claus).
H. spinifrons Claus.
Heterostylites longicornis (Giesbr.).
Disseta palumboi Giesbr.
Augaptilus longicaudatus (Claus).
Euaugaptilus filigerus (Claus).
E. hecticus Giesbr.
E. longimanus Sars.
E. nodifrons Sars.

Haloptilus acutifrons (Giesbr.).
H. angusticeps Sars.
H. bulliceps Farran.
H. longicornis (Claus).
H. ornatus (Giesbr.).
H. oxycephalus Giesbr.
H. plumosus (Claus).
H. spiniceps (Giesbr.).
Centraugaptilus rattrayi (T. Scott).
Arietellus aculeatus (T. Scott).
A. giesbrechti Sars.
A. setosus Giesbr.
Phyllopus helgæ Farran.
Candacia norvegica Boeck.
Mormonilla phasma Giesbr.

In certain areas, especially in the temperate zone, species that in the tropical region belong undoubtedly to the deep-water group may form an apparently normal ingredient of the surface-water fauna. Such a region is to be found off the west coast of North America in the San Diego region of the Californian coast, where such species as *Eucalanus elongatus* (Dana), *Gaidius pungens* Giesbr., *Undeuchæta bispinosa* Esterly, *Metridia lucens* Boeck and *Pleuromamma abdominalis* (Lubb.) have been taken frequently in the surface tow-net (*vide* Esterly, 1912). The majority of examples taken on the surface were obtained at night, and this is to some, and possibly a very considerable, extent to be attributed to daily vertical migration ; but it is possible that the presence of these species at a level sufficiently high to enable their daily vertical migration to bring them to the surface may to some extent be correlated with the upwelling of deep water which is known to occur along this coast, especially during the spring months.

Damas (1905), in his study of the Copepoda of the Norwegian Sea, found that certain species tended to occur at a given level. He remarks (*loc. cit.*, p. 22) : " *Metridia* apparait souvent dès 100 m. de profondeur, *Euchæta glacialis* parait aussi vivre dans une zone intermédiaire, tandis qu'*Euchæta barbata* appartient à la faune profonde." Wilson (1942, p. 8), in his account of the work of the " Carnegie " in the Pacific Ocean, also states that " the different species of copepods that are found near the surface of the ocean in the daytime show a marked tendency to arrange themselves in zones or layers parallel with the surface. Some species are practically confined to the surface tows, of which they constitute a very large percentage. . . . Others are confined entirely or very largely to the 50-metre tow, and still others apparently do not approach nearer to the surface than the 100-m. tow." The evidence that he gives is by no means conclusive. It is well known that many of the surface-living species are to be found at a lower level during the daytime and the depth to which they descend appears to be in the main correlated with the intensity of the light that is present, so that this varies from day to day (*vide infra*, p. 354). As regards the species that do not usually appear higher than the 100 m. tow-nettings, a study of Wilson's lists reveals that these are for the most part, if not entirely, species that normally inhabit much greater depths, and belong to the deep-dwelling group of species that has its maximum intensity at about 1000 m. depth. It is interesting to note that out of the 135

species listed above as many as 75 are known to be present in all three great oceans, Atlantic, Indian and Pacific, and 34 or 35 have been recorded from the Antarctic. Clearly these are widely dispersed species, and hence would be most liable to become involved in any unusual disturbance in the ocean that might set up convection currents and vortices and so bring the deep fauna to the surface.

Such an upward transference of individuals, belonging to species that normally inhabit deep and cold-water strata, into the warm upper-surface layer will expose them to a relatively rapid rise in the temperature of their surroundings, and, as we have already seen, such a change is likely to prove fatal; it will also expose them to a very considerable reduction of pressure. It seems doubtful whether such examples could survive this change, and in consequence whether such a vertical transference into a superficial current of the "Troposphere" could affect the horizontal distribution of the species as a whole. In certain instances, however, such an upwelling may perhaps not be immediately fatal, especially to immature stages, and so might permit of the transference over comparatively short distances, as from the Atlantic Ocean to the Mediterranean Sea (*vide infra*, p. 511). In the Atlantic Ocean a vertical upward movement from the depth of about 1500 m. to about 300 m. will be correlated with a change of temperature from about 3° C. to about 12° C., which is probably within the limits of tolerance of many of the species given above, and as at first the upwelling water will tend to retain the temperature of the zone from which it started and will only subsequently become warmed up to that of the upper level, any adverse effect on the individual will be delayed.

In a few areas the main factor limiting the horizontal distribution of a species appears to be, not temperature, but the salinity of the water, and Wilson (1942, p. 7) has pointed out that "a high salinity is known to be adverse to ordinary pelagic copepods, and it is possible that when combined with a fairly high temperature it may become a deterrent to copepod life in the epiplankton." Farran (1920, p. 15) remarks regarding the species *Calanus finmarchicus* (Gunn.), "This species is sometimes referred to as being oceanic because it is intolerant of inshore conditions, probably on account of low salinity, but high salinity seems to furnish an equally efficient bar to its seaward extension"; this seaward limit coincides approximately with the isohaline 35·35 ‰.

Another factor that must be considered is the ability of individual specimens to withstand changes of pressure, and especially of a reduction of pressure, such as must be experienced when being carried upwards in convection or other currents, and of many, if not most, species to become adapted to very greatly increased pressure, and hence to possess an equally great vertical range of habitat. As regards the effect on the individual Cattell (1936) has reviewed our knowledge of the subject, and he remarks: "The fact that deep-sea forms have as their normal habitat pressures great enough to produce important physiological changes and even death in organisms living near the surface is a significant observation which seems to have attracted very little attention since Regnard's pioneer studies." Regnard (1884 and 1891) carried out a number of experiments on various organisms, subjecting them to pressure of 400 to 1000 atmospheres. Cattell (*loc. cit.*, p. 454) sums up these experiments as follows: "Thus examples of surface fauna are killed when exposed to pressures comparable to those tolerated by deep-sea species, and conversely the deep-sea forms die when brought to the surface." As he points out, "the study is a difficult one, for in bringing a deep-sea animal to the surface not only is the pressure changed but many other environmental factors, such as light, temperature, and the concentration of dissolved

gases." Heilbrunn (1937, p. 348) states that "Cœlenterates exposed to 1000 atmospheres were inert and their weight about twice what it was originally. Similar effects were obtained with tunicates and worms. Crustacea, protected by their carapace, withstand high pressures better." That species are able to adapt themselves to a wide range of pressure is beyond doubt. The work of Farran (1926), Jespersen (1934) and others has shown that numerous species possess a wide vertical range, and hence are able to exist in a very considerable range of pressure. It is this ability to withstand a great range of pressure that enables species to be involved in the phenomenon of submergence. Ekman (1935, p. 323 *et seq.*) has pointed out that there are two types of such submergence, namely towards the poles and towards the equator, and it is the latter type that is most frequent. He further points out that both kinds of submergence are simple consequences of the temperature distribution, and that the submergence of the animal distribution runs parallel with the submergence of the water temperature and the water itself; in other words, the animals are carried downwards to deeper levels in the sinking polar or boreal water-masses, and at the same time are transported horizontally from one region to another. Giesbrecht (1892) stated most emphatically that deep-sea species of warm seas were *not* met with in the Arctic regions ; but it is now well known that certain species, as an example of which we may take *Pseudocalanus elongatus* (Boeck) (= *minutus* Kröyer), are common at or near the surface in the Arctic and Antarctic regions, but that in lower latitudes, near or at the equator, they are found to be living at considerable depths. Conversely Jespersen (1934) has shown that in West Greenland waters the warm-water, surface species *Paracalanus parvus* (Claus) was usually taken at considerable depths, with 1000 to 2500 m. of wire out, which he estimated (*loc. cit.*, p. 7) corresponded to an actual vertical depth of one-half or two-thirds of this figure, namely from 500 to 1667 m. Leavitt (1938), in his studies of the vertical distribution of the macroplankton in the western Atlantic basin, obtained evidence of two maxima, the one at about 800 m. depth and the second at about twice this depth, and he suggested that this deeper maximum can be accounted for on the supposition that "sinking water masses from more moderate depths in somewhat higher latitudes may bring their planktonic communities with them and so be responsible for richer strata below poorer further south. This (last) seems the most probable explanation for such a distribution in the present case, because species of decapods, copepods, cœlenterates and euphausiids occurring at moderate depths somewhat farther north have been prominent in the catches where total volumes have revealed the existence of secondary maxima deep down." Such a passive transference of species from the surface stratum in high latitudes both north and south of the equator is continually going on and is now recognized to be a well-established phenomenon. Russell (1935) has pointed out that "the ocean circulation is in favour of carrying any northern species that can withstand and reproduce under deep-water conditions southwards to the Antarctic." It is not every species that can resist the changes experienced in such a transfer, but a number of Arctic forms have been swept as far as the tropical region, where they are found in deep water, and still more have been carried from the north temperate region to the Sub-Antarctic area. Such a transfer does not, however, entail a very great change of temperature, and a gradual sinking from the surface in northern latitudes to a depth of 2000 m. in the tropics may be accompanied by a change of only some 2° C. in temperature ; and moreover such a change must be extremely gradual since the actual rate of flow of the deep currents is slow, though it may perhaps vary considerably from region to region and from depth to depth. Various attempts have

been made to estimate the speed of these deep currents: in the Antarctic, in the region to the east of South Georgia, the water of the upper stratum is moving northwards, but the rate of this movement varies very considerably at different depths, and Hardy and Gunther (1935, p. 348), quoting results obtained by Deacon, give the figure of 5·5 miles per day at the surface and of only 2·3 miles per day at a depth of 400 m. Wattenburg (1927) suggested a speed of some 3–4 cm. per sec. (or 511–683 miles per annum) in the Intermediate and Deep currents of the North Atlantic. Soule (1938), from a variety of different kinds of evidence, suggests that off the Grand Banks at 3500 m. depth the water is moving south at a speed of 6·6 cm. per sec. (or 1141 miles per annum), but that at a point to the south-east of the tail of the Grand Bank the speed is reduced to 2·6 cm. per sec. (or 438 miles per annum). Wüst (1935) quotes an estimate, reached by Castens from a study of the observations taken by the "Deutschland" and the "Dana," of 3·5 cm. per sec. (or 595 miles per annum), and he suggests that, if the observations on which all these calculations are made truly reflect actual changes due to movement of the various water masses, the upper deep stratum, the Sub-Antarctic intermediate water, moves northwards at a rate of 3·8 cm. per sec. (or 647 miles per annum) in the main axis of the stream, and that the middle deep water, the North Atlantic Intermediate water, moves southwards in the main axis of the current at a speed ranging from 3·5 to 3·8 cm. per sec. (or 595–647 miles per annum). Seiwell (1934 and 1938), from a study of the oxygen-content of the water of the North Atlantic, concludes that the rate of flow of the North Atlantic Intermediate water is only about 1·4 cm. per sec. (or 272 miles per annum), and Deacon (1933), basing his calculations on the differences of oxygen-content and salinity variations, postulates a speed of about 1·3 miles per day (or 474·5 miles per annum) in lat. 40° S. and 2·5 miles per day (or 912·5 miles per annum) in lat. 7° S. in the South Atlantic Intermediate water, the difference between these two estimates being due to the decreasing thickness of the layer and the narrowing of the Atlantic basin. It would thus take a mass of water and its contained plankton some 9 years or more to get from lat. 60° N. or S. to the Equator, which agrees moderately well with the suggested 7 years, as indicated by Deacon, to get from about lat. 40° S. to the Equator. During such an interval of time there will have been a succession of generations in the drifting Copepoda. In *Calanus finmarchicus* (Gunn.) there are known to be two or three generations in a year in the cold northern surface waters, and since there is little or no change in temperature in the water that is sinking down to form the Intermediate current, it seems probable that a similar rate of reproduction persists in the cold deep water of the equatorial region. The change of pressure that is entailed in such a transfer from the surface to a depth of some 2000 m. amounts to approximately an increase from one atmosphere, or 15 lb. to the square inch, at the surface to about 200 atmospheres, or 206·6 kg. per sq. cm., at 2000 m.; but this increase, great though it be, will be spread over some 18 or more generations, even if the drift be a continuous one in a straight North-South direction.

Rose (1925) has published a detailed survey of the various factors that can influence the daily vertical migration, and Russell (1927) has admirably summarized our knowledge, up to the date of publication of his paper, of the vertical distribution of the plankton, and he has grouped the various changes under the following headings:

1. Regional changes in vertical distribution.
2. Seasonal changes.
3. Daily changes.

4. Ontogenetic changes.
5. Changes due to spawning habits.
6. Special variations due to hydrographic conditions.

Most of the work on the subject of vertical migration has been carried out on organisms that inhabit the surface water of the Atlantic Ocean, and among the Copepoda it has been shown that *Calanus finmarchicus* (Gunn.) and *Candacia armata* Boeck (*vide* Russell, 1928, Gardiner, 1931, and Clarke, 1934*a*), *Centropages typicus* Kröyer (*vide* Clarke, 1933), *Metridia lucens* Boeck (*vide* Clarke, 1933), *Calanopia americana* F. Dahl (*vide* Clarke, 1934*b*), and *Acartia spinata* Esterly (*vide* Clarke, 1934*b*) appear to carry out diurnal migrations, swimming up towards the surface at night and sinking down to deeper levels in the day. Esterly (1912), working on the fauna of the Pacific Ocean, has shown similar daily vertical migrations in *Calanus finmarchicus* (Gunn.), *Metridia lucens* Boeck, *Labidocera trispinosa* Esterly, *Euchirella pulchra* (Lubb.), *E. rostrata* (Claus), *Gaidius pungens* Giesbr., *Pleuromamma abdominalis* (Lubb.), *P. gracilis* (Claus), *Rhincalanus nasutus* Giesbr. and *Undeuchæta bispinosa* Esterly. Hardy and Gunther (1935), working in the Antarctic region, have recorded evidence of similar migrations of a diurnal character in *Calanus similimus* Giesbr., *Clausocalanus laticeps* Farran, *Ctenocalanus vanus* Giesbr., *Drepanopus pectinatus* Brady, *Paraeuchæta antarctica* Giesbr., *Pleuromamma robusta* (F. Dahl) *Metridia gerlachei* Giesbr. and *M. lucens* Boeck; and Mackintosh (1934) has shown that similar migrations can be detected in species (unidentified) of the genera *Paraeuchæta, Euchirella* and *Heterorhabdus.* Russell (1928, 1932), from his studies in the Plymouth area, showed that at one season of the year a daily vertical migration of *Calanus finmarchicus* (Gunn.) appears to be a regular phenomenon, individuals coming up to the surface at night and migrating downwards in the daytime. Gardiner (1933), working in the North Sea, found, however, that the migration was of an exactly opposite nature, so far as adults and Stage V individuals were concerned, for the greater number were taken at or near the surface at mid-day and sank down to 28 fms. (51 m.) at midnight.

It is now generally accepted that one of the main factors that induce this daily vertical migration is the direction and intensity of the light at different depths, but other factors may be concerned, and Ostwald (1902) has put forward the view that the physico-chemical characteristics of the water and of the planktonic individual have a profound effect. The two most important factors in his mechanical theory of migration are the size and shape of the planktonic organism, which influences the amount of friction between the animal or plant and the surrounding water, and its specific gravity on the one hand, and the viscosity of the water, which is varied by changes of temperature and salinity or the degree of concentration of suspended material, on the other. Ostwald thus explains the daily vertical migration of the plankton as follows: at sunrise the plankton is found in greatest abundance on the surface; as the day advances the surface-water becomes heated up and this reduces the density of the water and decreases the friction and viscosity, so that planktonic organisms will begin to sink and will continue to do so till they reach a level at which the density of the water and its viscosity is sufficient to counteract the tendency of the organism to sink, and at that level the plankton will float freely. By night the plankton has become accumulated at a certain depth below the surface, but as the surface water cools it becomes more dense, and at the same time the deeper water becomes warmer and thus vertical currents are set up (the daily "change-over"), and the plankton is then carried mechanically to the surface again by the ascending currents

and will be found there in the early hours of the next day. Differences in different organisms will affect the extent and rapidity of these passive movements: larger organisms will sink more rapidly and to a greater depth than smaller ones, hence the adult Copepoda will reach a deeper level than the immature and larval stages; and powerful swimmers will have a greater amplitude of range than those less powerful.

One factor, therefore, that must tend to produce a stratification in the distribution of individuals of different sizes and developmental stages is the rate at which they will sink, if active swimming be suspended or be insufficient to counteract the rate of sinking. Gardiner (1933), from a study of anæsthetized individuals of *Calanus finmarchicus* (Gunn.), found that in the North Sea examples that were taken near the surface had an average length of 2·76 mm., those at mid-water 2·82 mm., and finally those from near the bottom averaged 2·94 mm. From the data that he gives (Table VIII) we are able to calculate the rate of sinking of the different developmental stages, as follows:

Stage.	Number of examples.	Range of size (length). (mm.)	Time taken to sink through 250 mm. of water. (Average.)
IV	21	2·1 to 2·4	124·1 seconds
V	41	2·6 ,, 3·2	99·35 ,,
VI ♀	53	2·8 ,, 4·0	59·3 ,,
♂	5	3·0 ,, 3·5	49·3 ,,

Gardiner also states that in the North Sea during the course of his investigations Stages IV and III did not sink down like the older specimens, and Nicholls (1933), in the Clyde Sea-area, noted that "the stimulus to withdraw from bright light does not affect the nauplii, but becomes increasingly effective as development proceeds, so that there is a tendency for the 3rd Copepodites to migrate downwards during the day. . . . In adults, particularly the females, heliotropism in *Calanus* is developed to its fullest extent."

A number of the surface-living Copepoda are known to exhibit a seasonal migration, occurring at or near the surface at one period of the year and inhabiting a lower stratum at another. Here again a number of factors appear to be involved. Russell found that in the Plymouth area adults of *Calanus finmarchicus* (Gunn.) were found at a depth of 10 m. in the month of April but were at 20 m. in June, and were found again to be nearer the surface in July, August and September. To explain this difference he suggests that successive broods may be physiologically different, some preferring a higher light intensity than others, though he qualifies this conclusion, pointing out that so little is yet known of the actual seasonal changes in light conditions beneath the surface that we cannot say that an apparent seasonal change in the behaviour and reactions of *Calanus* is not entirely due to changes in external conditions and not to any physiological difference at all. Several other Authors have recorded *Calanus finmarchicus* (Gunn.) to be swarming at the surface during the day in various regions in the following months:

Sömme (1933) in the month of April.
Marshall and Orr (1927) occasionally in April, and in May and June.
Brook (1886) in May and June.
Herdman (1919) in July.
Bigelow (1926) in July.
Russell (1928) in July and August.
Willey (1919) in September.

Mackintosh (1937) has shown that in Antarctic waters such a seasonal vertical migration may be extremely marked : thus *Rhincalanus gigas* Brady is to be found in large numbers in the upper layer between 0 and 200 m. in December, whereas in September there are very few in the surface layer and the great majority occur at about 500 m. *Calanus acutus* Giesbr. in September has completely deserted the surface layer and has sunk to depths as great as 750–1000 m. or even more, but in December it appears on the surface. Mackintosh relates this vertical migration to the movements of the antarctic water layers, and he remarks, " It is to be supposed that this vertical migration results in a large-scale circulation by means of which these species keep within the limits of their normal distribution."

Nikitine (1929) points out that this seasonal migration seems to be determined by temperature. When the temperature of the water rises in summer above a critical point certain species of planktonic organisms descend to a lower and cooler level, and with the advent of winter, as the surface water cools, they ascend again to the surface. *Calanus finmarchicus* (Gunn.) is found in the winter months to leave the surface when the temperature rises above 15° C. and descends to a depth of 90–130 m. In the Black Sea these seasonal movements of *Calanus finmarchicus*, according to Nikitine, coincide almost exactly with the isotherm of + 13° C. In the Mediterranean Sea, Rose (1924) has shown that this species occurs in the superficial stratum in January to April, rarely in May, when the temperature has a mean of 15·37° C. During the rest of the year it is found between 0–70 m. depth, where the temperature is less than 15° C. This critical temperature differs in different species ; thus for

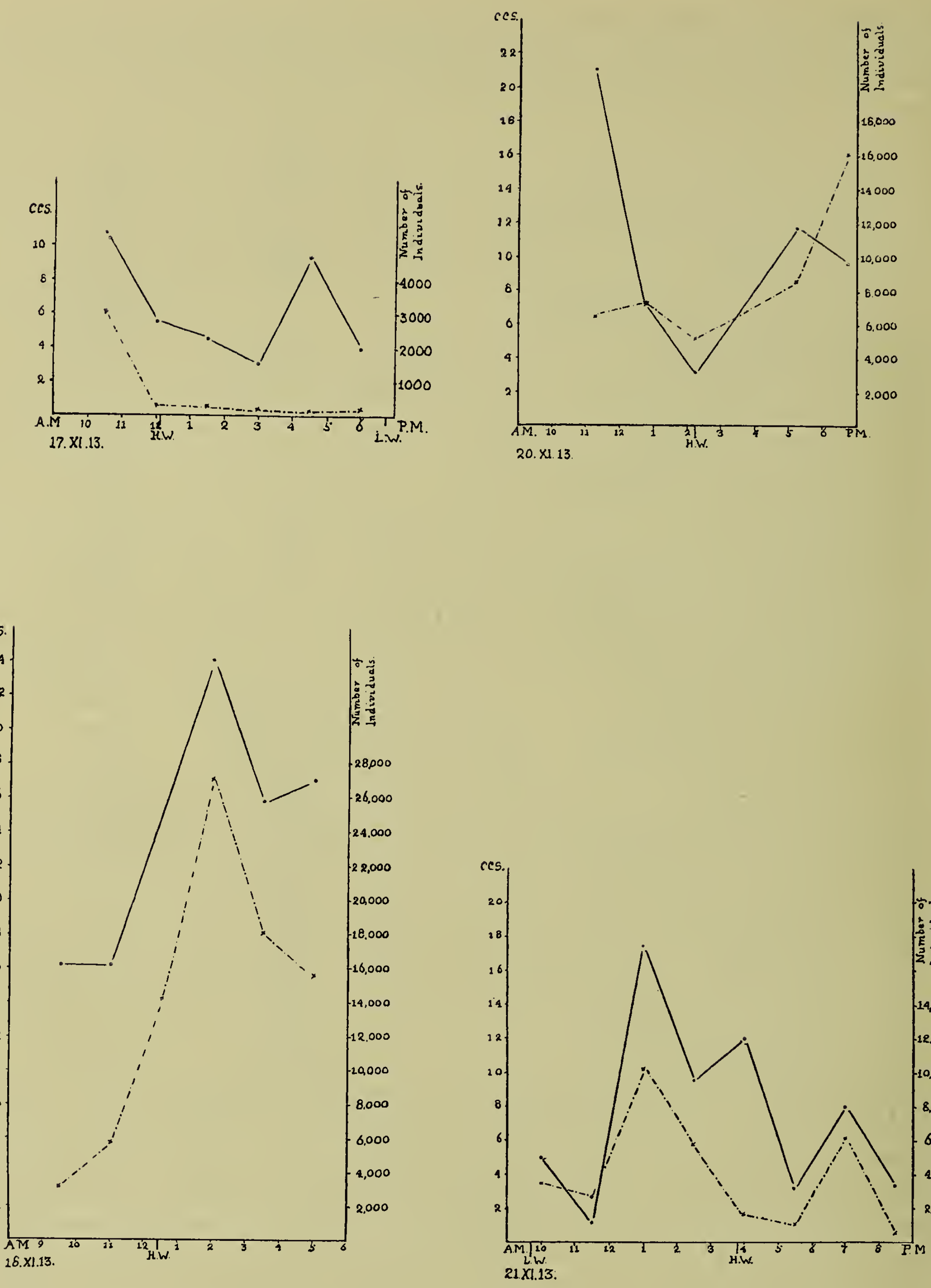
Calanus finmarchicus (Gunn.)	it is	+ 15° C.
Oithona similis Claus (adult)	,,	+ 14° C.
Pseudocalanus elongatus (Boeck)	,,	+ 13° C.

Centropages kroyeri Giesbr. appears to have a critical temperature of + 17° C., since this isotherm marks the limit of its horizontal range, and hence in the Black Sea it does not exhibit any seasonal migration. It seems possible that the " layering " of individuals of different size and stages of development may largely be the result of differences in the relative density of the animals and the sea water, as suggested by Ostwald. Lowndes (1942) gives the sinking factor of *Calanus finmarchicus* (Gunn.) as 1029 or 1033 at 15·4° C, whereas in *Anomalocera patersoni* Templ., a surface-living form that shows no daily vertical migration, it is as low as 1014, and in *Tigriopus fulvus* (Fischer), a bottom-living form, it is as high as 1060. This sinking factor must vary very considerably during the year, for Bogorov (1934) has pointed out that spring and summer *Calanus* are reddish-yellow and have abundant fat inclusions ; winter specimens are greenish-white, and lack fat inclusions or have only very slight ones, presumably owing to reduced winter nutrition : and Marshall, Nicholls and Orr (1934) have shown that there is a marked increase in fat in the body during the months April to September, and that in both male and female *Calanus* the three broods can be recognized by the change in the fat content. Specimens with abundant fat inclusions must possess a lower specific gravity than those without and this may well modify the rate of sinking, and might even abolish any tendency to sink and so cause the individuals to remain near the surface, thus counteracting the tendency to migrate downwards into cooler water during the summer. Gardiner (1931) has pointed out that, subject to certain limitations, " the use of single vertical hauls to study the distribution of the plankton in both space and time may be expected to give reliable results." During my

investigations of the "John Murray" collections I made a careful count of the total number of examples of different species that were taken in two hauls at the surface at Station 61, during the day and at night respectively. The results, as regards some of the species, are as follows :

Species.	Day haul.	Night haul.
Nannocalanus minor (Claus)	120	14,280
Calocalanus plumulosus (Claus)	0	1,080
C. pavo (Dana)	240	600
Clausocalanus furcatus (Brady)	120	11,280
Paracalanus aculeatus Giesbr.	0	10,680
P. denudatus Sewell	240	8,280
P. parvus (Claus)	0	2,760
Undinula vulgaris (Dana)	0	240
U. darwini (Lubb.)	0	3,120
Euchœta marina (Prestand.)	0	1,205
E. wolfendeni A. Scott	960	7,086
Euchaeta sp. juv.	720	12,240
Labidocera detruncata (Dana)	120	6,890
Pontellina plumata Dana	0	360
Pontellopsis regalis (Dana)	0	120
Acartia erythrœa Giesbr.	0	120
A. amboinensis Carl	120	240
Oithona plumifera Baird	0	1,680
Oncœa mediterranea Claus	4,440	14,160
O. media Giesbr.	6,482	14,040
Corycella gibbula (Giesbr.)	15,485	3,280
? *Corycœus rostratus* Claus	1,560	0
C. gracillicaudatus Giesbr.	360	120
C. speciosus Dana	960	0
C. latus Dana	240	0
? *C. curtus* Farran	240	0
Centropages gracilis (Dana)	1,200	324
C. orsinii Giesbr.	120	120

The day haul was carried out for an hour from about 1.30 p.m. to 2.30 p.m. and the night haul was made between 1.30 a.m. and 2.30 a.m., and the net was of fine silk with a diameter at the mouth of 50 cm., the same net being used for each haul. The total quantity of Plankton taken was 170 c.cs. in the night haul and 52 c.cs. in the day. From the above figures it is clear that many species were much more frequent on the surface during the night, as compared with the numbers taken in the day ; but as regards the genera *Corycœus* and *Corycella* the exact opposite was the case. In these two genera far more examples of six species were taken by day. If these differences between the two hauls are due to migration from one stratum to another, it seems probable that the species of *Corycœus* and *Corycella*, unlike so many other species of the epi-plankton, come up towards the surface by day and sink down to a lower level during the night ; the same seems to hold good for *Centropages gracilis* (Dana). It must, however, be pointed out that during the



Text-fig. 78.—Variations in the total amount of plankton and the number of Copepoda present during the day at "Investigator" Sta. 566, lat. 11° 57′ 30″ N., long. 98° 19′ 00″ E., on 17–18.xi.1913, and Sta. 567, lat. 11° 54′ 00″ N., long. 98° 18′ 45″ E., on 20–21.xi.1913. H.W., high water. L.W., low water. ——————Total plankton in c.c's. – · – · – · – Number of Copepoda.

course of our observations the ship had drifted from lat. 23° 02′ 48″ N., long. 64° 31′ 54″ E. to lat. 23° 02′ 12″ N., long. 64° 33′ 39″ E.; it is thus possible that we were sampling two distinct water-masses.

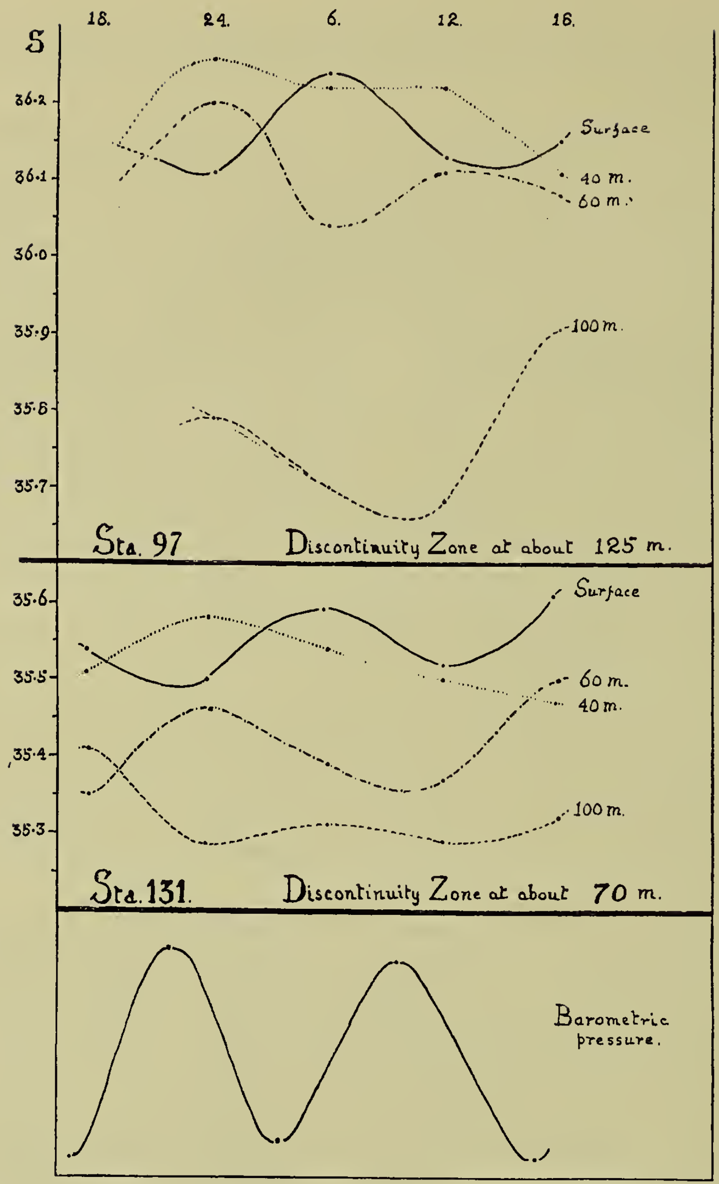
In a series of observations carried out by me in the Mergui Archipelago off the coast of South Burma in 1913 a very great variation in the numbers of Copepoda present in the surface water was detected. In these observations the ship was at anchor, and a silk net was suspended just below the level of the surface and the tidal current allowed to flow through. The net remained down for half-an-hour and the total number of Copepoda captured was counted: at the same time the rate of flow of the current was taken and the number of Copepoda per knot current was calculated. The same net was used throughout. Although the method was crude and made no allowance for the different rate of flow through the net with currents of different strength, it serves to give an indication of the relative richness of the catches at different times of the day. In all four series (*vide* Text-fig. 78) the catch was low between 9 and 11 a.m., rose to a first maximum between 12 noon and 2 p.m., dropped again between 4 and 5 p.m. then rose to a second maximum about 7 p.m., and on the last day sank again to a minimum between 8 and 9 p.m. That this double variation was not due to tidal changes is indicated by the different position of the times of high and low water on the curves on different days; nor can it be attributed to a diurnal migration under the influence of light. There are, however, certain other physical factors that may produce differences in the density of the fauna at any given level, and up to the present time these do not appear to have received the attention that they deserve: such factors are (1) a periodical "change-over" of the surface water under the influence of some factor other than that of heating by solar activity and evaporation, and (2) oscillatory movements of the deeper strata.

As regards the first factor, I have pointed out (Sewell, 1928, p. 186, and 1929, p. 296) that observations taken in the Bay of Bengal and Revello Channel in the Nicobar Islands in the month of October show a clear daily double rise and fall of the surface salinity, alternating with the rise and fall of the barometric pressure, whereas off the west coast of India in April and May we get a similar double rise and fall of the surface salinity now coinciding with the rise and fall of the barometer; this difference is apparently due to the fact that at one season of the year the surface stratum has a higher salinity than that at a lower level and at the other season the reverse is the case, the surface water having a lower salinity than that lower down. Very similar variations were found to be present at Stations 97 and 131 in the Arabian Sea during the "John Murray" Expedition in December, 1933, and February, 1934, respectively. I give the data of these two stations below and the results have been plotted in Text-fig. 79.

Sta. 97, 21.xii.33. Lat. 10° 56′ 18″ N., long. 59° 55′ 24″ E. Salinity ‰.

Depth in metres.	Time of day. 21.xii.33. 0.00.	6.00.	12.00.	18.00.
0	36·11	36·24	36·13	36·15
20	36·26	36·26	36·13	36·13
40	36·26	36·22	36·22	36·11
60	36·20	36·04	36·11	36·08
80	36·18	35·93	35·93	35·97
100	35·79	35·70	35·68	35·91

Discontinuity zone at about 125 m. depth.



TEXT-FIG. 79.—Showing the salinity at different depths at different times of the day at "John Murray" Stations 97 and 131.

Sta. 131, 10–11.ii.34. Lat. 1° 39′ 06″ S., long. 61° 13′ 48″ E. Salinity ‰.

Depth in metres.	10.ii.34. 17.30.	10.ii.34. 23.45.	11.ii.34. 5.45.	11.ii.34. 12.00.	11.ii.34. 17.30.
0	35·54	35·50	35·59	35·52	35·61
20	35·52	35·52	35·53	35·52	35·52
40	35·51	35·58	35·54	35·50	35·47
60	35·35	35·46	35·39	35·37	35·50
80	35·36	35·37	35·31	35·30	35·35
100	35·41	35·28	35·31	35·29	35·32

Discontinuity zone at about 70 m. depth.

For comparison I have given in the figure the rise and fall of barometric pressure. At both stations the salinity on the surface exhibits a clear tendency to alternate with the rise and fall of the barometric pressure. At 40 m. depth in both series the salinity shows a maximum at 24·00 hrs. and then falls steadily to 18·00 hrs. In the series from Sta. 97 at a depth of 60 m. the salinity again shows a double rise and fall during the day that here tends to run with the barometric pressure, having a primary maxima at about 24·00 hrs. and a secondary maximum at about 12·00 hrs.: no such curve, however, is shown at Sta. 131. At this depth at the latter station the salinity exhibits a curve that exhibits two maxima at about 24 hrs. and 18 hrs. If now these changes are due to vertical movements of the water particles under the influence of evaporation or, as I suggested in a previous paper (Sewell, 1928 and 1929), as a result of variations in the wind force, such changes can only affect the stratum above the discontinuity zone, which at Sta. 97 lay at a depth of about 125 m., but at Sta. 131 at about half this depth, namely, 70 m. We should therefore compare the curve at 60 m. depth at Sta. 131 with that at 100 m. at Sta. 97, and it is clear that the two curves are remarkably similar.

Sets of serial observations taken at standard depths in a single locality at intervals during the day are extremely rare in many regions and are practically non-existent for the Arabian Sea, but Pearson (1922), in the Ceylon Administration Report for 1921, gives several series taken consecutively in different localities but within short distances, and I give his results below:

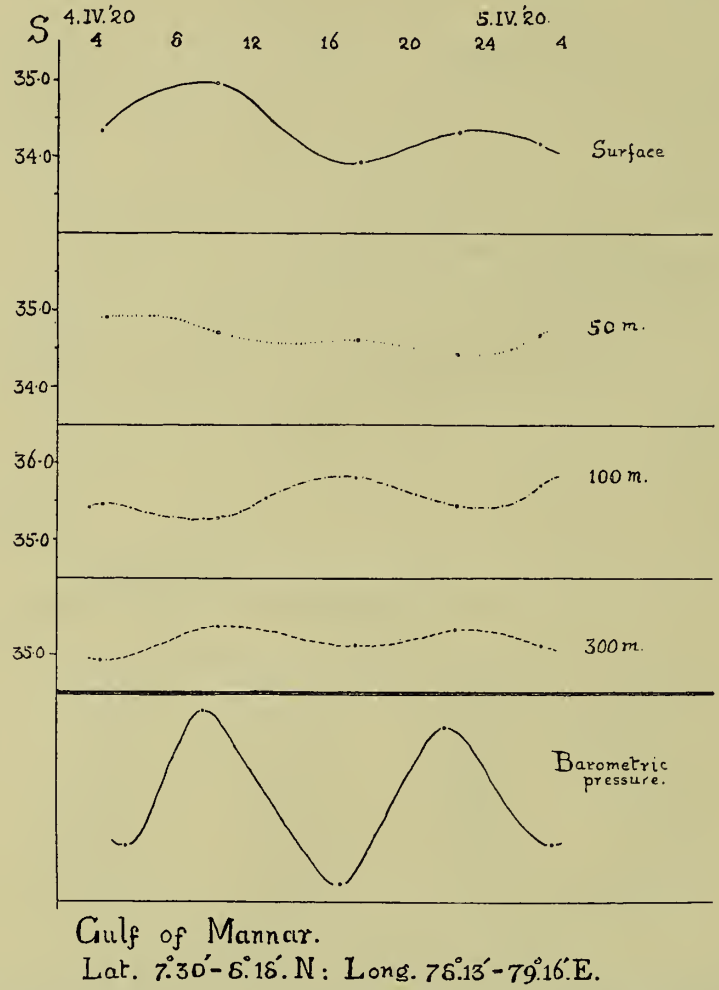
Gulf of Mannar. 4–5.iv.20. Lat. 7° 30′–8° 18′ N., long. 78° 13′–79° 16′ E. Salinity ‰.

Depth in metres.	Time of day. 4.iv.20. 3.37–5.0.	4.iv.20. 9.50–11.20.	4.iv.20. 17.18–18.20.	4.iv.20. 22.10–23.10.	5.iv.20. 2.28–3.28.
0	34·34	34·00	33·93	34·29	34·23
50	34·99	34·72	34·63	34·45	34·67
100	35·46	35·26	35·53	35·48	35·71
200	35·35	35·23	35·14	35·07	35·32
300	34·90	35·35	35·14	35·32	35·10

There was no evidence of any Discontinuity zone in this area as far down as 300 m., below which no observations were taken. I have plotted these results in Text-fig. 80. Here too we find that the surface salinity exhibits a double rise and fall in 24 hours, but this curve differs from those exhibited at the two "John Murray" stations in that the rise and fall coincides with the barometric changes. At 50 m. depth we again get a slight single daily rise and fall, having its maximum at about 4·0 hrs. At 100 m. depth the salinity again shows a double rise and fall, but this now alternates with the rise and fall of barometric pressure and the salinity on the surface. At 300 m. the salinity still exhibits a slight double rise and fall, but at this depth there has been another change and the curve again follows the barometric pressure. The reason for the difference in the surface curve at this station and those at the "John Murray" Stations is clearly to be found in the fact that here the surface salinity is lower than that at some depth below. It thus seems possible, if not probable, that the double daily rise and fall in the quantity of the

surface plankton is correlated with this double daily " change-over " of the surface water under the influence of a double daily rise and fall in the strength of the wind force, but modified and influenced by other factors such as the rise and fall of the tide and variation in the intensity of the sun's rays and the temperature of the surface water.

Somewhat similar oscillations have been recorded in the Gulf of Maine (*vide* Clarke, 1934*a* and 1934*c*), where at a depth of from 10 to over 80 m. the temperature of the water changed very considerably twice in 24 hours, rising to a primary maximum at about



Text-fig. 80.—Showing the salinity at different depths at different times of the day in the Gulf of Mannar.

5–6 hrs., with a secondary maximum at about 18 hrs. As Clarke points out, such a change, that at one time was so rapid that the temperature at a depth of 28 m. altered from 7° C. to 12° C. in three hours must have been produced by vertical oscillation of the whole stratum, and this must have carried with it the planktonic population. Seiwell (1937) has also called attention to similar vertical oscillations in the western part of the North Atlantic, and he concludes that these are to a large extent associated with the tidal wave. In a later paper (1939) he states that " continuous temperature measurements at fixed depths over time intervals up to 12 days show average daily vertical displacements of 38 to 227 m., the larger value occurring where the water is least stable." Such vertical displacement of

the water particles must be accompanied by a similar displacement of the plankton, and hence no explanation of the vertical " migration " of such organisms as the Copepoda can be complete which does not take congnizance of these vertical oscillations and convection currents in the water strata.

Another type of oscillation, differing from the above in that it exhibits a longer " period," has also been noted in various regions and has been attributed to a " seiche " in the deeper stratum, the length of the time period depending on the depth and configuration of the area and the difference in salinity of the upper and lower strata. In several coastal areas round the Bay of Bengal I have shown (*vide* Sewell, 1928, p. 179) that the surface salinity shows a periodic rise and fall, and I have explained this as a result ot a " seiche," or swinging of the deeper stratum ; accompanying each rise there was evidence of an increase in the number of planktonic organisms, and in some cases of the appearance of organisms that were normally absent ; this I attribute to a mixing of the water of the lower stratum with that of the surface layer by wave action when the lower stratum approaches sufficiently near to the surface to be affected. It thus seems possible that variations in the number of organisms present at any given level in any area may be due, not to active migration of the organisms themselves, but to purely passive movement brought about by changes in the level or the character of the stratum of water in which they are living.

Russell (1931) suggested that the upward migration of planktonic organisms that seems to be so frequently met with in the Plymouth and other regions may be impeded by obstructing animals, large numbers of other animals in the plankton causing a modification of the behaviour to be expected. Hardy and Gunther (1935) have put forward the view that a dense phytoplankton population has an excluding influence on the smaller zooplankton. They point out that, with few exceptions, where the phytoplankton is dense, zooplankton is scanty and appears to be able to avoid such patches. They remark that " the smaller members of the zooplankton, the Copepoda, the Pteropoda, to say nothing of the Foraminifera, obviously could not make such swimming migrations ; yet our results suggest that they have the power of distributing themselves horizontally in relation to the phytoplanktonic production in the upper layer. The power of vertical migration, which so many of these organisms possess, would seem to be their means of ' navigation '." The authors discuss the causation of this departure from the usual habit of the plankton to come up to the surface at night and sink down to a deeper level by day ; and they conclude that the agency does not seem to be mechanical, but is probably chemical, and acts by altering the rate, extent (spatially) and length of time of the vertical migration ; and they have suggested a number of factors, such as the length of time required to obtain a full meal, alterations in the pH of the water causing a change from negative to positive phototropism, the effect of higher O_2 concentration, etc., but they have not considered the possibility that a dense phytoplankton may render the water more viscid, and so may affect the daily " change over " of the water strata. Whatever the causative agent, by altering their level the zooplankton may be brought into a current moving more slowly than the surface water or even moving in a different direction, and so get carried away from the dense phytoplankton patch.

Redfield (1941, p. 96), when studying the influence of the water circulation on the distribution of the Calanoid Copepoda in the Gulf of Maine, has also pointed out that since several species exhibit a well marked diurnal migration, " the population cannot be

identified exclusively with any particular layer, and any attempt to correlate its distribution with the drift of the water is complicated by the undoubted migration of the animals to and from layers of different depth moving with different velocities and in some places without doubt in different directions." If such a vertical migration can be brought about at great depths, it will serve to convey the organism from one mass of water into another of entirely different origin, as, for instance, from the surface water, or "troposphere" of Defant, into the uppermost stratum of the "stratosphere," namely the Antarctic intermediate water. In a few instances evidence has been obtained that a vertical migration may be carried out in considerable depths; thus Esterly (1911*a*) obtained evidence that seemed to him to indicate thet *Eucalanus elongatus* (Dana) carried out migration that resulted in a concentration of individuals at a depth of about 366 m. (200 fms.) by day and a general dispersal at night. Hardy and Gunther (1935) give evidence that tends to show that in Antarctic waters the species *Scolecithricella minor* (Brady) carried out a vertical daily migration as deep as from 500 to 700 m. Welsh, Chace and Nunnemacher (1937) have also obtained some evidence that in the western region of the North Atlantic the copepoda living at a depth of 400 m. show a similar daily vertical migration, so that here too it may be that at least certain species by such migration pass from the upper surface water into the North Atlantic intermediate water, or *vice versa*. It is also probable that along the boundary zone between two water masses moving in different directions, vortices will be set up that will transfer some of the plankton from one water mass to the other, and it is obvious that any such transfer may have a profound effect on the geographical distribution, if the species is capable of surviving in its new habitat.

Damas (1905) asks, How does the plankton of a given region maintain its character in the face of the continual circulation of the currents, and how does a given species persist so as to possess a special geographical distribution ? He concludes that there must exist a special zone or centre of production in which adults abound and reproduce successfully, and that around this region there is a circulatory current. He remarks, "L'existence d'une zone spéciale où abondent les adultes, zone qui se continue directement dans la région la plus riche en oeufs, larves et jeune individus, indique que l'espèce se maintient grâce à l'existence dans ces régions d'un courant circulatoire qui ramène périodiquement une certaine proportion des individus répandus à la surface de l'Ocean et entrainés dans la mouvement continuel des eaux." Damas envisaged a horizontal circulation, but a further possibility is that a certain proportion of a species may by vertical migration reach a different stratum of water from that in which they were originally living, and this new stratum may be flowing in the opposite direction to the current that is carrying them away from their breeding ground or general habitat; as a result, either the young or the adults of the succeeding generation may be swept back to their original position. It is well known that many species of copepods may ascend to higher levels when spawning, so that the young forms are met with in strata above that in which the adult is usually found. With (1915, p. 28) remarks, "It seems to be a general rule that the younger the stage of development, the nearer the surface do the specimens live, as pointed out by Damas, Paulsen and Farran."

This rule is certainly not universal, for in certain species and in different localities the position of adults and young stages may be reversed. Störmer (1929) has shown that in the sub-arctic region of the North Atlantic the young stages of both *Calanus finmarchicus* (Gunn.) and *Pseudocalanus elongatus* (Boeck) (= *P. minimus*) occur at a higher level than

the adults ; whereas in the case of *Paraeuchæta norvegica* (Boeck) in this region the young stages were found occupying a lower level than the adults, and With (1915, p. 65) also notes that as regards the form of *Pseudocalanus elongatus* (Boeck), known as *P. gracilis*, the adults were found to be common at depths between 480 and 800 m., whereas the young stages were met with between 800 and 1000 m. Wolfenden (1904) and With (1915) agree that the young forms of *Paraeuchæta norvegica* (Boeck) in the North Atlantic and the region round Greenland are not uncommon at or near the surface, while the adults are in the deeper strata from 914–1097 m. (500–600 fms.). In the catches of the "John Murray" Expedition in the Arabian Sea I have already pointed out (*vide supra*, p. 328) that the young stages of certain species occurred at a higher level than the adults.

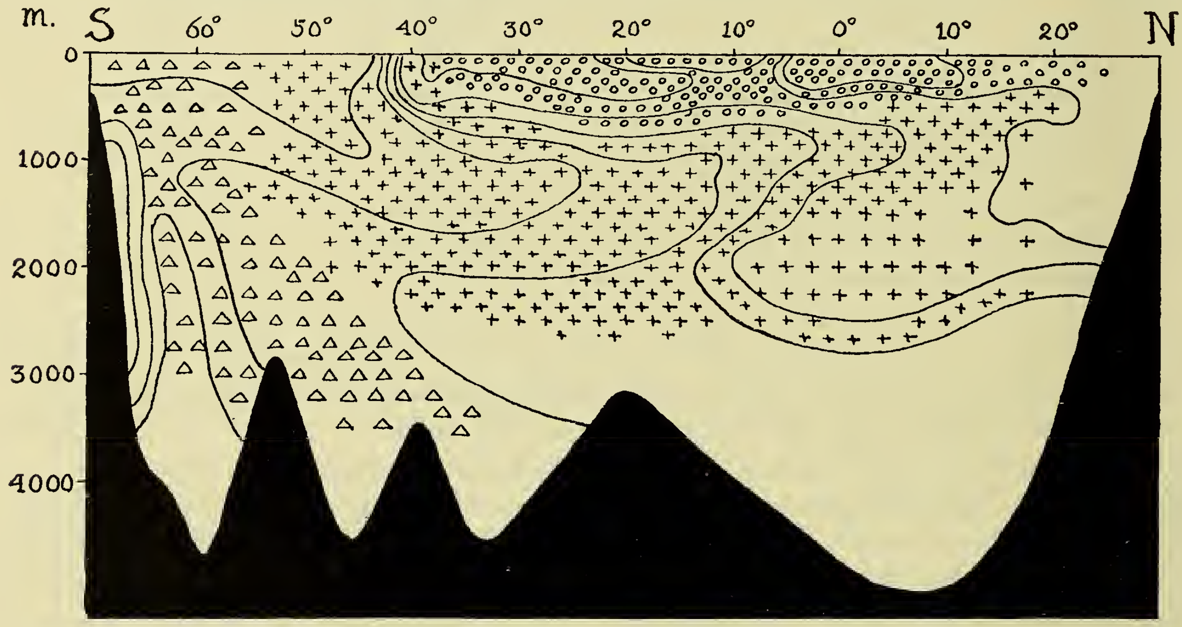
Species.	Upper level of appearance of— Young stages (m.)	Adults (m.)
Undeuchæta bispinosa Esterly	100	300
Euchirella galeata Giesbrecht	100	400
Pleuromamma abdominalis (Lubb.)	200	400
Pseudochirella magna (Wolf.)	300	400 to 645
Onchocalanus trigoniceps Sars	600 to 650	850
Bathycalanus bradyi Wolf.	1500	2500

Such differences as these suggest that the adults and young are respectively inhabiting different strata of water, such as the surface stratum and the Indian Intermediate current or the Intermediate current and the Antarctic Bottom Drift.

Schmaus and Lehnhofer (1927, p. 392, figs. 28 and 29) have given charts of the distribution of the genus *Rhincalanus* in the Atlantic and Indian Oceans ; unfortunately in their chart of the Atlantic region they have attempted to correlate the distribution with the scheme of the deep currents suggested by Schott (1902, p. 164, fig. 33), in which he postulated intermediate currents from both poles flowing towards the equator and there combining to form an ascending mass of water. They thus show *Rhincalanus nasutus* as occupying two quite distinct regions in the North and South Atlantic Oceans respectively, and between these a gap extending from approximately lat. 10° N. to 10° S., in which no examples are said to be found. The later work of Steuer (1931*b*) has indicated that in the Atlantic Ocean this species inhabits in the main the North Atlantic Intermediate water, but is absent from the western part of the South Atlantic. In Text-fig. 81 I have attempted to indicate the distribution of the species of this genus in the Indian Ocean *Rhincalanus cornutus* Dana, f. *typica*, like f. *atlantica* in the Atlantic Ocean, is an inhabitant of the upper surface stratum or troposphere, and its distribution can be accounted for by horizontal water movements : *R. nasutus* Giesbr. possesses a distribution that comprises in its upper portion the water mass of the Sub-polar or Antarctic intermediate stratum and in its lower region the Indian intermediate current ; thus the young stages, inhabiting the upper levels of its distributional area, will be swept from south to north, while the adults, inhabiting the deeper levels, will be carried southwards. The third species, *Rhincalanus gigas* Brady, has a distribution that extends throughout the Antarctic region and the Antarctic bottom water in both the Atlantic and Indian Oceans, but, at any rate in the Indian Ocean, its distributional area comprises in its upper

part a portion of the Indian intermediate current, and in consequence the young stages will be swept southwards towards the South Pole while the adults in the lower level will be carried northwards. Hardy and Gunther (1935, p. 356), in their work in the Antarctic region, obtained evidence that they interpret as showing that the species *Scolecithricella minor* (Brady) experiences a similar transference : " It appears that these animals, on being carried by the surface layer to the limit of the Antarctic zone, may descend, as a balloonist would from one air current to another, and make use of the great oceanic current system to return into the Antarctic zone again in the intermediate layer, flowing back towards the Pole." I have already referred to Macintosh's work on *Rhincalanus gigas* Brady (*vide supra,* p. 356).

In attempting to trace the geographical dispersal of these planktonic forms it is essential that one should take a wide view of what constitutes a species, and one must also bear



TEXT-FIG. 81.—The distribution in the Indian Ocean of the species of the genus *Rhincalanus*.
○ *Rhincalanus cornutus*. + *R. nasutus*. △ *R. gigas*.

in mind that the adaptability to new conditions may vary greatly. Runnstrom (1927) has pointed out that certain forms during their development are limited to a particular fixed temperature range, which is for that species a physiological constant and, consequently, such species are limited to a fixed area of distribution ; but that in other species a greater range may be tolerated, and these species may evolve into physiological races adapted for life in different conditions, and hence may possess a wide geographical range. Appellöf (1910) and Störmer (1933) have further pointed out that we may get one or more such physiological races within the limits of the same morphological species, or, as Störmer puts it, " we cannot always regard the morphologically determined species as being physiological units in the geography of animals." We may during the course of evolution get a series of stages passing from a single morphological and physiological species, through a morphological species with several physiological races, and then by slight differences of structure to a species in the wide sense with several morphologically distinct races or forms, and finally to distinct but very closely related species.

It has for a long time been recognized that the average size of examples of a given species tends to vary in different localities in which they are living, and that this is in all probability due to differences in the local conditions. At the present time our knowledge of the conditions in many of the areas in which collections have been made is not sufficient to enable us to assign such differences as have been noted to any one specific causative agent, and it is probable that a number of different factors are implicated. Murray and Hjort (1912, p. 693) remark, "First of all, in organisms which cannot lower their specific gravity by depositing fats or absorbing water, we find a dominant tendency to develop minute forms in specifically light water," and Steuer (1923, pp. 38 *et seq.*), reviewing our knowledge up to the time of writing, emphasizes that "im leichten Wasser das Körpervolumen sich verringert, im schweren Wasser sich vergrössert."

I have already given a table showing the range of salinity that is tolerated by certain species living on the coast of Burma (*vide supra*, p. 325), and I give below a few examples of the extreme range of salinity that is tolerated by certain other species :

Species.	Extreme range of salinity ‰.
Acartia clausi Giesbr.	Freshwater to 36·00
A. bifilosa Giesbr.	0·30 ,, 32·00
Pseudodiaptomus tollingeræ Sewell	0·17 ,, 11·84
P. annandalei Sewell	0·17 ,, 18·94
P. binghami Sewell	0·17 ,, 18·94
Temora longicornis Müll.	6·54 ,, 36·16
Acartia longiremis (Lübb.)	6·72 ,, 35·32
Pseudocalanus elongatus Boeck	7·25 ,, 35·30
Pseudodiaptomus serricaudatus (T. Scott)	10·85 ,, 43·80
Centropages hamatus (Lillj.)	13·5 ,, 23·90
Oithona nana Giesbr.	13·68 ,, 43·80
Labidocera pavo Giesbr.	14·12 ,, 32·00
Paracalanus parvus (Claus)	19·33 ,, 43·80
Metridia lucens Boeck	28·10 ,, 35·40
Calanus finmarchicus (Gunn.)*	29·00 ,, 35·30
Acrocalanus gibber Giesbr.	32·95 ,, 35·50

Where a wide range of salinity is tolerated one would expect to find differences in size, and in some species these have been recorded, as, for instance, in the following :

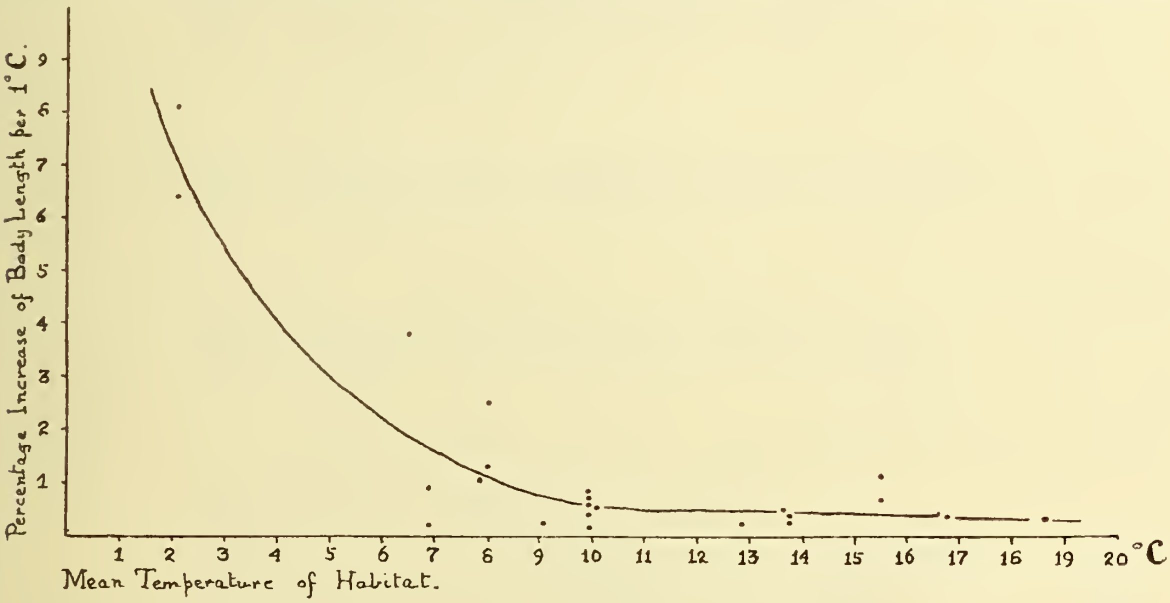
Species.		Locality.	Total length. (mm.)
Acartia clausi Giesbr.	♀,	Brackish water	0·70–0·83
		North Sea	1·47
	♂,	Brackish water	0·71–0·82
		North Sea	1·31
Acrocalanus gibber Giesbr.	♀,	Bay of Bengal	0·81
		Bitter Lakes, Suez Canal	0·86

* Stalberg (1931) has recorded the presence of a variety of *Calanus finmarchicus*, which he has named *teleykensis*, in the Teleyker Sea in Altai, in water of low salinity, 60·8 mg. per litre.

Labidocera pavo Giesbr.	♂,	Indian Ocean	1·12–1·20
		Red Sea	2·12
Centropages tenuiremis Thomp. and A. Scott	♀,	Gulf of Aden	1·50
		Puri, Bay of Bengal . . .	1·71
		Ceylon Pearl Banks . . .	1·80
	♂,	Puri, Bay of Bengal . . .	1·43
		Gulf of Aden	1·50
		Ceylon Pearl Banks . . .	1·80

But in most instances a difference in salinity between two localities is accompanied by other changes in the local conditions. A change of salinity alone, in so far as this is produced in the ocean by evaporation or by dilution with rain-water, will merely affect the density of the water in which the animal is living, and hence will expedite or retard the rate at which the individual tends to sink or rise according to whether the density of the surrounding medium is below or above that of the animal itself. A change of temperature, however, will produce a two-fold effect : it will, like a change in salinity, alter the density of the medium, but at the same time it will act directly on the organisms accelerating or retarding the vital processes, according as the temperature rises or falls, and thus will affect the length of life of the organism, the time of onset of maturity, and hence, perhaps, the size to which it will grow : but experiments carried out by Coker (1933) cn *Cyclops vernalis* Fischer throw some doubt on this last point. Coker remarks that " our general observations on several species of Copepoda does not at all bear out the supposition of a causal relationship between the length of the period of development and the greater size at maturity." It is, however, now well recognized that in any given locality in which there is a well-marked seasonal variation in temperature we find an equally well-marked seasonal change in the size of individuals of any given species, if these have more than one generation in the year. The seasonal changes in size and body-mass of *Calanus finmarchicus* (Gunn.) have been studied by Bogorov (1934), who has given numerous references to earlier work on this subject ; he summarizes his conclusions as follows : " A definite relation is obvious between size of organism and hydrological conditions, the main factor being temperature, particularly during the period of development. Thus the large sized ' spring ' generation was hatched at 8°–9° C. of temperature ; the smaller ' summer ' generation at 10·5°–14·5° C. ; the very smallest ' autumn–winter ' generation at the warmest temperature of 15°–16° C." Thus during the course of a year one form gives rise to another, this phenomenon being known as " cyclomorphosis." Bogorov agrees with the conclusion drawn by Adler and Jespersen (1920) that the size attained is inversely proportional to the temperature in which the individual was living during its development. Jespersen (1937) has shown that the arctic Calanoid, *Calanus hyperboreus* Kröyer, also exhibits certain variations in size, and that " a comparison between the average length of *Calanus hyperboreus* and the hydrological conditions at the different stations shows distinctly that the temperature is an important factor," and that " the smallest sizes of this copepod are found in waters mixed with that from the Atlantic having temperatures above 3° C., while the larger sizes predominate in water with a negative temperature and up to 1·2° C. Furthermore, it is of interest in this connection to draw attention to the fact that the distribution of the large sizes of *Calanus hyperboreus* is in

all essentials identical with the areas of West Greenland waters where the large individuals of *Calanus finmarchicus* predominate." Steuer (1937) has given the results obtained from a study of the material obtained in the Atlantic Ocean by the "Meteor," and here too he has found that the size attained by individuals of the species *Pleuromamma abdominalis* (Lubb.) f. *typica* and *Pleuromamma robusta* (F. Dahl) varies with the temperature of the water, and especially of the water at a depth of about 100 m. Bogorov (1934), from his study of the bio-mass of individuals of the same species under different temperature conditions, reached the conclusion that "the value of the difference in temperatures depends on its place on the temperature scale, the influence of smaller differences in temperature under lower conditions having a greater effect than large differences at higher temperatures." In order to see how far the present series agrees with this finding, I have in a number of species calculated the percentage increase in the total body-length for every



TEXT-FIG. 82.—Showing the percentage increase in the total body-length for each 1° C. difference in the temperature of the habitats at different temperatures.

change of 1° C. in the temperature, and the results are given in the following table.* In the majority of cases the size differences are taken from a number of individuals captured at the same station but at different depths, but in a few instances the measurements are of specimens taken at different depths at different stations. In the accompanying figure (Text-fig. 82) I have plotted the percentage increase in the total body-length for each 1° C. difference in the temperatures of the habitats against the mean temperature at which the individuals were living, and the result thus obtained certainly appears to indicate that throughout the range of temperature from 20° to 10° C. there is only an extremely small increase in size, but that below 10° C. the percentage increase in length goes up rapidly.

That variation in temperature is not the only factor affecting the size of the organism is clear from the different results that have been observed in different localities. Rzoska (1932) has shown that at a high altitude *Cyclops strenuus* Fischer exhibited a variation in size that coincided with the change in temperature, specimens being larger in summer and

* In addition to my own observations I have included those made by Bogorov (1934) on *Calanus finmarchicus*, by Sömme (1929) on *C. hyperboreus*, and by Steuer (1937) on *Pleuromamma robusta*.

Temperature interval. (° C.)	Range. (° C.)	Mean temperature. (° C.)	Size variation. (mm.)	Difference. (mm.)	Increase °/°° per 1° C.	Species.
4·7 to − 0·5	5·2	2·1	3·22 –4·57	1·35	8·06	*Calanus finmarchicus* (Gunn.).
4·7 ,, − 0·5	5·2	2·1	6·0 –8·0	2·0	6·40	*C. hyperboreus* Kröyer.
8·7 ,, 4·38	4·32	6·5	4·9 –5·7	0·80	3·78	*Gætanus kruppi* Giesbr.
9·5 ,, 4·38	5·12	6·9	4·97 –5·37	0·40	1·65	*Pleuromamma xiphias* Giesbr.
9·5 ,, 4·38	5·12	6·9	4·275–4·319	0·044	0·21	,, ,, ,,
11·5 ,, 4·38	7·12	7·94	6·25 –6·718	0·468	1·05	*Lophothrix frontalis* Giesbr.
11·27 ,, 8·69	2·58	9·98	5·219–5·315	0·096	0·71	*Eucalanus elongatus* (Dana), adult.
11·27 ,, 8·69	2·58	9·98	4·366–4·445	0·079	0·61	,, ,, ,, Stage V.
11·27 ,, 8·69	2·58	9·98	3·424–3·460	0·036	0·41	*Rhincalanus cornutus* Dana.
11·27 ,, 8·69	2·58	9·98	3·794–3·875	0·081	0·83	*Eucalanus pseudattenuatus* sp. nov.
11·27 ,, 8·69	2·58	9·98	4·430–4·520	0·090	0·79	*Pleuromamma xiphias* Giesbr.
12·5 ,, 8·7	3·8	10·6	5·143–5·254	0·111	0·57	*Lophothrix frontalis* Giesbr.
12·38 ,, 5·75	6·63	9·06	4·198–4·264	0·066	0·24	*Rhincalanus nasutus* Giesbr.
11·27 ,, 8·69	2·58	9·98	4·221–4·235	0·014	0·13	,, ,, ,,
14·0 ,, 11·77	2·23	12·88	2·268–4·292	0·024	0·25	*Pleuromamma xiphias* Giesbr.
14·0 ,, 2·0	12·0	8·0	3·32 –4·32	1·00	2·52	*P. robusta* (Dahl), ♀.
14·0 ,, 2·0	12·0	8·0	3·11 –3·59	0·48	1·28	,, ,, ♂.
14·59 ,, 12·69	1·90	13·64	4·212–4·252	0·040	0·50	*Rhincalanus nasutus* Giesbr.
16·27 ,, 11·27	5·0	13·77	3·353–3·424	0·071	0·42	*R. cornutus* Dana.
16·27 ,, 11·27	5·0	13·77	4·160–4·221	0·061	0·29	*R. nasutus* Giesbr.
25·0 ,, 6·00	19·0	15·5	3·11 –3·53	0·42	0·71	*Pleuromamma robusta* (Dahl), ♀.
25·0 ,, 6·00	19·0	15·5	2·68 –3·28	0·60	1·18	,, ,, ,, ♂.
26·0 ,, 11·35	14·65	18·67	3·204–3·378	0·174	0·37	*Rhincalanus cornutus* Dana.
27·8 ,, 5·75	22·05	16·77	3·618–3·955	0·337	0·42	*Eucalanus pseudattenuatus* sp. nov.

smaller in winter, whereas at low altitudes both this species and *Cyclops vicinus* Ulj. showed a variation alternating with the temperature, examples being larger in winter and smaller in summer. To account for the differences in size of *Sagitta elegans* Verrill and *Sagitta setosa* J. Müller in the Plymouth area, Russell (1932, p. 136) has suggested that "it is probable that the size reached is conditioned amongst other things by the amount and type of food eaten, the temperature conditions and the length of life, and that the latter depends on the time of onset of maturity," but Coker (1933) in his experiments on *Cyclops vernalis* Fischer, to which I have already called attention, found that though deficiency of food-supply may cause a retardation or even arrest of development, it does not appear to have any effect on the size attained.

That factors other than temperature may effect the size of individuals is also indicated by Marshall (1933), who states that in *Calanus finmarchicus* (Gunn.) in the Clyde Sea-area "in general the size was greatest when the water temperature was low, and least when it was high, but beside this there was a series of increases and decreases in size, which were apparently connected with the breeding periods." In a previous paper (Sewell, 1934*b*) I showed that in a natural fresh-water environment in India two species of Calanoids, *Diaptomus viduus* Gurney and *D. contortus* Gurney, and two species of Cyclopoida, *Cyclops leuckarti* (Claus) and *C. rylovi* Smirnov, exhibited a double size variation during the year, a primary maximum occurring during the cold winter months, December–January, and a secondary maximum during the hot months, April–June ; and between each maximum is a corresponding minimum. I pointed out that "the chief increase in reproductive activity seems to correspond with the period during which we find the maximum increase in the general size of the individual."

Since a number of factors appear to be involved, it is not surprising that in many species we find very considerable differences in the size of individuals taken in different localities, and I give below a few examples :

Species.	Total length in mm. Atlantic Ocean.	Indian Ocean.	Pacific Ocean.
Eucalanus crassus Giesbr.	3·4 –3·6	3·0	3·0
E. subtenuis Giesbr.	2·65–3·4	2·03	2·7
Euchæta marina (Prestand.)	2·24–4·0	3·0–3·68	3·0–5·0
Lucicutia flavicornis (Claus)	1·47–1·58	1·47	1·60
Labidocera detruncata (Dana)	3·0	2·81	2·25–2·80
Bradyidius armatus (van Höffen)	2·4	1·2	..
Disseta palumboi Giesbr.	6·36–7·0	7·0	5·7–8·3
Euaugaptilus longimanus Sars	5·3–5·8	9·5	..

It is also now well known that in many species examples taken at different depths may exhibit differences in size, those from higher levels being smaller than those from deeper down. This difference in size is usually given as the explanation of the fact that in most species the males, which are smaller than the females, are to be found at a higher level. Here too it seems probable that more than one factor is involved, for experiments conducted by Coker (1929) on *Cyclops vernalis* Fischer reared in the laboratory showed that "males greatly predominate in cultures reared at high temperatures, females in those reared at low temperatures, with no regularity of predominance at intermediate temperatures."

Thus it may be that the increase in the number of males in a higher stratum than that occupied by the majority of the females may possibly be in part due to the effect of higher temperature on development, causing a majority of the ova in the warmer layer to develop into males, and not be due to any correlation between the size of the individual and the density of the water. Steuer (1931) has given the depth distribution of the various species in the two genera, *Rhincalanus* and *Copilia*, and he has shown that in the former genus the males are smaller than the females and are found to inhabit a higher level, whereas in *Copilia* the converse is the case, the males being larger than the females and occurring in deeper strata. Even in members of the same sex, differences can be detected in examples taken from different depths in the same locality. Clarke has noted such differences in examples of species taken in the upper levels of the sea, and he gives a table showing the results of his measurements, which I reproduce below :

Length measured Cephalothorax (excluding Abdomen), to end of Lateral Spine, if present.

Metridia lucens Boeck.

Depth. (m.)	Average size, ♂. (mm.)	Average size, ? sex. (mm.)
42	1·296	1·466
78	1·342	1·458
114	1·356	1·583

Calanus finmarchicus (Gunn.).

Depth. (m).	Adult. ♀.	Stage V.	Stage IV.	Stage III.
6	2·445	2·152	1·664	1·263
42	2·589	2·305	1·707	..
114	2·766	2·328	1·787	..

With (1915) considers that *Pseudocalanus elongatus* Boeck, *gracilis* Sars and *major* Sars are in reality examples of the same species, and that such differences as have been noted are due to the different depths at which the examples were living :

Pseudocalanus elongatus Boeck, length 1·40 mm. near the surface.
P. gracilis Sars, ,, 1·65 ,, at 600 m. depth.
P. major Sars, ,, 2·4 ,, at 800–1350 m. depth.

Farran (1926) described from the Bay of Biscay two forms of *Spinocalanus abyssalis* Giesbr., f. *typica* and f. *pygmæus* ; both forms appear to have a depth range of from 200–1000 m., but Farran suggests that the smaller form, *pygmæus*, has its optimum at a somewhat higher level than the larger, namely from 300–500 m. In the "John Murray" Expedition a sufficient number of examples of a few species were taken at different depths, and I have measured these and have calculated the average length of the individuals of each catch. I give these results below, and for each catch I have given the estimated depth at which the haul was made and the approximate temperature of the water at that depth. It must, however, be borne in mind that the given depth can only be regarded as approximate, for the nets used were not, with very few exceptions, self-closing. Usually the nets were lowered to the required depth, and they were then hauled, as far as was possible, horizontally for an hour and then were hauled to the surface, fishing all the way. The records of the Depth-recorder, attached to the net, showed that the depth of the net during a haul varied very considerably.

Species.	Sex.	Sta.	Average depth of haul in metres.	Temperature. (°C.)	Average length. (mm).
Rhincalanus cornutus (Dana)	♀	172	200	16·27	3·354
			400	11·27	3·424
			850	8·7	3·464
	♀	96	10	26·08	3·204
			645	10·5	3·378
Rhincalanus nasutus Giesbr.	♀	76	600	12·38	4·198
			1500	5·75	4·264
	♀	172	200	16·27	4·160
			400	11·27	4·221
			850	8·68	4·235
	♀	186	250	14·6	4·212
			600	12·69	4·252
Eucalanus attenuatus (Dana)					
Adult	♀	172	400	11·27	5·219
			850	8·68	5·315
Stage V	♀	172	400	11·27	4·366
			850	8·68	4·445
Adult	♂	172	400	11·27	4·027
			850	8·68	4·101
Stage V	♂	172	400	11·27	4·019
			850	8·68	4·101
Eucalanus pseudattenuatus sp. nov.	♀	61	10	27·8	3·618
			1000	9·0	3·843
			1500	5·75	3·845–3·955
		172	400	11·27	3·797
			850	8·68	3·875
Pleuromamma xiphias (Giesbr.)					
f. *minor*	♀	131	500	9·5	4·275
			1500	4·38	4·319
	♀	172	400	11·27	4·430
			850	8·69	4·520
	♂	172	400	11·27	4·759
			850	8·69	4·618
	♀	186	600	14·0	4·268
			950	11·77	4·292
	♂	186	600	14·0	4·558
			950	11·77	4·547
f. *major*	♀	131	500	9·5	4·967
			1500	4·38	5·379
	♂	131	500	9·5	5·017
			1500	4·38	5·554

It is interesting to note that in some species the rule that a lower temperature is correlated with an increase in size appears not to hold good, as for instance in the males of *Pleuro-*

mamma xiphias f. *minor* at Stas. 172 and 186. If now we contrast examples taken at different stations and arrange the length measurements according to the temperature in which they were living at these different stations, we get the following results :

Rhincalanus cornutus (Dana).

	Temperature. (°C.)	Average depth of haul in metres.	Sta.	Average length. (mm.)
♀	26·08	10	96	3·204
	16·27	200	172	3·353
	14·0	575	186	3·368
	12·12	645	96	3·378
	11·27	400	172	3·424
	9·67	500	131	3·349
	8·7	850	172	3·464

Rhincalanus nasutus Giesbr.

	Temperature. (°C.)	Average depth of haul in metres.	Sta.	Average length. (mm.)
♀	16·27	200	172	4·160
	14·59	250	186	4·212
	12·69	500	186	4·252
	12·38	600	76	4·198
	11·27	400	172	4·221
	8·68	850	172	4·235
	5·75	1500	76	4·264

Eucalanus attenuatus (Dana).

	Temperature. (°C.)	Average depth of haul in metres.	Sta.	Stage V.	Stage VI.
♀	27·8	10	61	4·161	..
	12·59	600	186	4·301	4·954
	11·27	400	172	4·366	5·219
	10·4	645	96	4·245	5·113
	9·67	500	131	4·080	..
	8·68	850	172	4·445	5·315
♂	27·8	10	61	3·069	..
	12·59	600	186	3·987	..
	11·27	400	172	4·019	4·027
	10·4	645	96	3·972	3·900
	9·67	500	131	..	..
	8·68	850	172	4·101	4·101

Pleuromamma xiphias (Giesbr.) f. *minor*, adult.

Temperature. (°C.)	Average depth of haul in metres.	Sta.	♀.	♂.
14·0	600	186	4·268	4·558
11·77	950	186	4·292	4·547
11·27	400	172	4·430	4·759
9·5	500	131	4·275	..
8·69	800	172	4·520	4·618
4·38	1500	131	4·319	..

While on the whole the average length shows a steady increase with a fall of temperature, it is clear that at certain depths and at certain stations the size of the examples taken was

smaller than one would expect. These localities are at Sta. 76, depth 600 m., Sta. 96, depth 645 m., and Sta. 131, depths 500 and 1500 m. It thus seems probable that in these localities there is some factor other than temperature that is affecting adversely the rate of growth. A study of the hydrographic conditions at these stations 76, 96 and 131 shows that in each case at the depth indicated examples were living in the mass of water that forms the Indian intermediate current and is characterized by a marked deficiency of oxygen-content (*vide infra*, p. 535).

If, as is believed, the temperature of the water in which individuals are living is the main factor in the production of variation in size and that the effect is produced during development, it follows that we should, in those localities that exhibit a seasonal variation in temperature at the depths concerned, be able to trace a corresponding variation in the total length of specimens taken at approximately the same depth in different months of the year. Such evidence as I possess is not sufficient to demonstrate this beyond any possibility of doubt, but I give below tables of data in regard to two species that appear to indicate that such variation is to be found, but that the effect on the body-length does not occur simultaneously with the change of temperature, but after an interval of time, the length of which differs at different levels, those species that inhabit less deep water, and so are living at a somewhat higher temperature, exhibiting a shorter time lag than those that live in deeper and colder water.

Eucalanus pseudattenuatus sp. nov.

	Month.	Approximate temperature at 200 m. (° C.)	Total length. Stage V. (mm.)	Total length. Stage VI. (mm.)	Month of capture.
♀	October	17·0	3·000–3·333	3·618–3·955	November.
	November	16·3	3·315	3·888	December.
	December	15·0	..	..	January.
	January	13·0	3·322	4·000	February.
	February	14·3	3·050	3·600	March.
	March	13·5	3·300–3·316	3·794–3·875	April.

Eucalanus attenuatus (Dana).

	Month.	200 m.	400 m.	Stage V.	Stage VI.	Month of capture.
				4·161	..	November.
				4·245	5·113	December.
♀	October	12·0	10·25	..	..	January.
	November	12·1	10·65	4·08	..	February.
	December	11·2	10·5	..	..	March.
	January	10·5	8·2	4·366–4·445	5·219–5·315	April.
	February	10·5	8·8	4·301	4·954	May.
				3·069	..	November.
				3·972	3·950	December.
♂	October	12·0	10·25	..	..	January.
	November	12·1	10·65	..	..	February.
	December	11·2	10·5	..	..	March.
	January	10·5	8·2	4·019–4·101	4·027–4·101	April.
	February	10·5	8·8	3·987	..	May.

In *Eucalanus pseudattenuatus* sp. nov., that has an optimum distribution in the upper levels, a comparison of the average total length and the average temperature at a depth of 200 m. indicates that the maximum average size of the adult female and to a less extent of Stage V is attained in the month of February, while the lowest temperature is found in January. In *Eucalanus attenuatus* (Dana), however, the maximum average length of both Stage V and the adult of both sexes occurs in April, whereas the minimum temperature at 400 to 600 m., where this species has its optimum, occurs in January–February at 400 m. and in January at 600 m. ; in this species there is thus a lag of three months. Such a difference would be quite in keeping with Bogorov's conclusion that the temperature in which a species is living affects the size attained by the adult by acting during the process of development, and the suggestion made by Russell that at lower temperatures the rate of development is retarded, maturity being attained later, so that the size to which an individual can grow is increased.

Coker (1933, 1934) has carried out some interesting experiments on the influence of temperature on the size and structure of certain fresh-water Copepoda, and he has shown that " Copepods reared at the lowest temperatures used are invariably so much larger than those reared at the highest temperatures that the difference is quite obvious to the naked eye," and he also showed that in one species, *Cyclops vernalis* Fischer, structural changes could be detected that seem definitely to be correlated with differences in the temperature at which they were reared : he found that " the length of the furca, like the length of the body as a whole, is inversely correlated with the temperature at which the copepods are reared. The correlation for both sexes is plain and unmistakable, the mean length of the furca for each temperature class being the less the higher the temperature of rearing." It is interesting to note that this difference is exactly that met with in varieties or races of two species of the genus *Cyclopina*. Sars (1918–23, p. 12) notes that the variety of *Cyclopina gracilis* Claus, that was recorded by Boeck under the name *C. norvegica* Boeck, possesses caudal rami that are comparatively shorter than in the typical form, and it occurs in shallow creeks and pools left by the tide. Again, the variety of *Cyclopina longicornis* Boeck, described by Brady under the name *C. littoralis* Brady, differs from the typical form in being of smaller size and having the caudal rami less elongated (*vide* Sars, *loc. cit.*, p. 13) : here again the variety lives in the littoral zone, whereas the typical form occurs in deeper water. We should thus expect to find in any given species variations in size and possibly also in structure in specimens collected in (1) different geographical regions, and (2) the same region but at different depths or at different seasons. As regards the first the literature abounds with numerous examples. Wolfenden (1906, p. 992) remarks : " It is well known that species, apparently the same, found in the boreal region have, when compared with those of the more southern and warmer areas, often undergone some variation (especially is this the case as to average size), and that some are known to vary greatly within certain defined limits." In a number of species that possess a wide geographical range slight differences of structure have been noted in examples from different localities. Wolfenden (1906) called attention to the differences that exist between specimens of *Paracalanus parvus* (Claus) and *Bradyidius armatus* (van Höffen) from the North Atlantic and the Indian Ocean ; Steuer (1917) described a local race of *Acartia* (*Odontacartia*) *pacifica* Steuer from the Aru Islands, and Früchtl (1924) has recorded a number of varieties and forms in other species from the same area. namely :

Centropages furcatus (Dana) var. *carli*,
Acartia (*Odontacartia*) *erythræa* Giesbr. var. *brehmi*.
Oithona brevicornis Giesbr. f. *aruensis*,
O. brevicornis Giesbr. f. *arostrata*,
O. attenuata Farran, var. *latithoracica*,
O. attenuata Farran, var. *latithoracica* f. *trisetosa*,
O. simplex Farran f. *quinquesetosa*,
Corycæus (*Ditrichocorycæus*) *andrewesi*, Farran var. *Rouxi*,
C. (*Ditrichocorycæus*) *asiaticus* F. Dahl var. *mertoni*,

but, as he points out, it is at present impossible to determine to what extent such forms and varieties may be attributed to individual, local or seasonal variation. Gurney (1927*a*) has pointed out that the structural differences between the northern and southern forms of *Paracalanus parvus* (Claus) are exceedingly small and that it is impossible to separate two varieties, but he adds, " On the other hand there is no doubt that there are two races which are, for the time being, separated by the isthmus " (of Suez) ; he also notes that in the Suez Canal area " there are two distinct forms of *Oithona nana*," with slight structural differences, and these he terms typical *Oithona nana* and a southern form. Steuer (1926, p. 56) has recorded from the East Pacific and West Atlantic regions two forms of *Tortanus discaudatus* Thomp. and A. Scott that might be regarded as sub-species. Schmaus and Lehnhofer (1927) have called attention to the Indo-Pacific and Atlantic forms of *Rhincalanus cornutus* (Dana) and have named these f. *typica* and f. *atlantica* respectively. Farran (1929) noted slight differences in the shape of the 5th leg of the female in examples of *Temoropia mayumbæensis* T. Scott, taken in the South-west Pacific region and off the west coast of Ireland, and A. Scott (1909) suggested that the Irish form should be regarded as a distinct species. Again, Farran (1929) has noted slight differences in the number of serrations on the inner margin of the basal segment of the 5th pair of legs in *Calanus finmarchicus* (Gunn.) from northern and southern waters.

As such small differences become more marked, the various forms will come to be regarded as different species ; but for such structural differences to become fixed it would appear to be necessary that there should be at least some degree of isolation. In a few instances this isolation may have been brought about by orographical changes ; thus Stillman Wright (1936) has suggested that two species of *Pseudodiaptomus*, *P. culebrensis* Marsh and *P. marshi* Wright, may have been derived from a common ancestor, and that their separation was effected in Eocene or Miocene times by the upheaval of the Central American Isthmus. In other instances isolation may have been ensured by certain individuals becoming adapted to a different range of physico-chemical characters. Hjort (1911, p. 371) has pointed out that " these (physico-chemical) conditions characterize a given species quite as much as any morphological description, and in fact, for a proper conception of the species both methods of investigation are supplementary." Michael (1911, p. 160) however goes somewhat further and, as regards the Chætognatha, he considers that a species may be defined " as much from the physical environment in which it is normally found as from its morphological characters." It is now generally recognized that one may get so-called biological species within the limits of a morphological species, but for the purpose of this review I prefer to regard such an adaptation as facilitating, and perhaps actually inducing, morphological changes that will eventually result in the evolution of a new species with definite morphological characters. Among littoral-haunting species

it is easy to see that local currents may carry individuals from one region to another in which conditions are essentially different, and I have in a previous paper (Sewell, 1940, p. 128 *et seq.*) called attention to certain slight differences of structure that may perhaps be associated with such local conditions.

Steuer (1935) has put forward the view that in circum-equatorial neritic species there is a tendency for these to become dispersed northwards towards the pole, and thus by invading the extensive coast-line of the northern hemisphere to give rise to variations or species ; as an example he cites the genus *Paracartia*, in which we have the following species :

Paracartia grani Sars, from the coasts of Europe.

P. latisetosa Kriczagin, from the Mediterranean Sea, Black Sea and Suez Canal.

P. dubia T. Scott, from the tropical region of West Africa.

P. africana Steuer, from the sub-tropical west African region.

Although it is at present impossible to make any definite statement as to the manner in which these various species have become distributed to their present localities, it is clear that in such coastal regions it is possible for races to be isolated and later to develop into different species, and this will have been particularly easy in the case of species that inhabit brackish-water, if such areas were originally portions of a continuous zone that at some later stage became divided either by the encroachment of pure marine conditions or by orographic changes, as instanced by Willey (1923) in his comparison of the faunas of two stations on the Canadian coast, namely Miramichi estuary and the Basin of Minas : as this author remarks, " while these stations are actually separated by a topographical boundary, the Isthmus of Chignecto, connecting Nova Scotia with New Brunswick, they belong to the same hydrographical system, namely the Acadian sub-basin. The observed distribution of *Pseudodiaptomus* on the east coast of North America is the resultant of former channels of dispersal." In the case of widely distributed oceanic species it is, however, less easy to visualize how a sufficient degree of isolation can have been maintained for a sufficiently long time to permit of such evolution so long as individuals were confined to the open sea and to the same depth, though it is clear that examples might be carried by currents into regions having considerable differences in conditions of temperature and salinity, such as enclosed bays or river estuaries, and numerous instances are to be found in the literature of local varieties of such wide-spread species. Steuer (1923, pp. 7, 40) has drawn attention to the variability of *Acartia clausi* Giesbr. In this species he at first recognized a " giant " race inhabiting the North Atlantic Drift and a " dwarf " race in the Canary Current, but in a later paper (1929) he concludes that these different forms are not geographical races but are correlated with the density of the water in which they are living, and he thus accounts for the presence of the giant race in the Adriatic, where the density of the water is higher even than in the North Atlantic Drift. In the Table below I give the length measurements of the species from different localities :

	Total length.	
	♀.	♂.
Brackish-water :		
(Gurney)	0·70–0·82	0·71
(Farran)	0·70	..
(Gurney)	0·83	0·76–0·82

	Total length.	
	♀.	♂.
Marine :		
New Zealand (Farran)	1·12–1·25	1·05–1·18
East coast of North America (Wilson)	1·15–1·25	1·0–1·1
North Atlantic Drift (Steuer)	1·131–1·265	1·04–1·124
North Sea (Gurney)	1·47	1·31
Norwegian coast (Sars)	1·15	1·0
Bay of Biscay (Farran)	1·2	1·08–1·18
Adriatic (Steuer)	1·222–1·307	1·131–1·209
Canary Current (Steuer)	0·977–1·07	0·99

Associated with these differences in size there are differences in the armature of the posterior margin of the 5th thoracic segment, the number of spinules increasing from 0 in the smaller forms to as many as 5 or 6 in the larger forms. Steuer has given a table showing the number of spines present in specimens from different localities, which I reproduce below, and to which I have added other observations :

Locality.	Number of spinules on the posterior thoracic margin.			
	♀.		♂.	
	Left.	Right.	Left.	Right.
East coast of North America	0		..	
North Atlantic Drift	1–6	1–5	2–5	2–5
Norwegian coast	4–6		..	
Adriatic	2–4	3–5	4–6	3–5
Canary Current	0–3	0–4	0	0
	(exceptionally 7)			

Steuer raised the question whether, since these spines seem to be correlated with the size of the specimen and the water of the North Atlantic Drift and of the Canary Current have a common origin in the Gulf Stream, these differences will disappear in specimens from the western area of the Atlantic, but, as he remarked, at the time of writing we then knew nothing regarding the occurrence of this species in the western region. Since then Wilson (1932) has recorded that in specimens taken in the Woods Hole region of the American coast these spinules are absent. Variation on parallel lines has been found to occur in another species of the same genus : in 1913 I noted that specimens of *Acartia centrura* Giesbr. taken in the brackish water of the Chilka Lake, India, were smaller in size than those taken in the open sea, and that the spines on the posterior margin of the 5th thoracic segment and the distal border of the abdominal segments are smaller than usual in this species. Gurney (1931, p. 224) considers that a definite brackish-water or estuarine form of *Acartia clausi* can be recognized ; and a distinct variety has been described as var. *gaboonensis* T. Scott, from the coastal region of the Cameroon Bight in the Gulf of Guinea, and a sub-species, *Acartia clausi hudsonica* Pinney, from Hudson Bay and the mouth of the St. Lawrence River in America. One of the commonest of deep-sea species, *Eucalanus elongatus* Dana, also appears to undergo structural variations as we trace it eastwards from the Atlantic Ocean, through the Indian Ocean to the Pacific. The Atlantic form was recorded by Claus under the name *hyalinus*, and Giesbrecht (1895) described a variety, *inermis*, from the Pacific. Johnson (1938) has suggested that this Pacific form should be

regarded as a distinct species, but examples taken in the Indian Ocean are intermediate between the forms *hyalinus* and *inermis*.

At first sight it would seem to be unlikely that there can be in any given level of the ocean, in which the changes in oxygen concentration, pH concentration, salinity and temperature are relatively small, such differences as could explain the evolution of local races : nor is it easy to see how any variety that may occur can be sufficiently isolated to permit of the formation of particular races or sub-species, unless the vertical migration is sufficiently great to carry examples from one current system to another either in the same or in a different ocean. That slight changes in structure, associated with changes in size, are not confined to surface-living forms, but may also occur in deep-water forms, seems to be indicated by the presence in the Indian Ocean of a variety of the North Atlantic species, *Candacia norvegica* Boeck, namely var. *tropica* Sewell, that was described by me (1932) from the Laccadive Sea. Similarly, the species *Euchirella bitumuda* With is a North Atlantic species, and its place is taken in the Indo-pacific region by *E. galeata* Giesbrecht. Farran (1926, p. 253) considers these two forms to be distinct species, but the differences are so slight that they may equally well be regarded as geographical races of a single widespread species, comparable to the two forms, Indo-Pacific and Atlantic, of *Rhincalanus cornutus* (Dana). In the genus *Pleuromamma* Steuer (1932) has described a number of different forms, which he has attempted in some degree to correlate with definite water masses : unfortunately in many instances he refers to the locality from which examples were obtained by the name of the surface current, although the depth at which the specimens were taken shows that they were too deep for this water and must have been living in a different water mass. In *Pleuromamma gracilis* (Claus) he recognizes three forms : f. *minima*, as its name implies the smallest, occurs in the upper levels between 150 and 400 m. depth in the tropical and sub-tropical regions of the North Atlantic ; it has been taken in the Canary Current at 150 m., in the Benguela Current at 350–500 m., in the Gulf of Guinea at 400 m., and in the South Equatorial Current at 200 m. ; in the Irminger Current it occurs at 400 m., in the Labrador Current at 700 m., and in the Sargasso Sea between depths of 450 and 700 m. It is now known that the warm water of the Irminger Current sinks downwards off the west coast of Greenland, and turning first west and then south forms the intermediate mass of water in the Labrador Sea between 500 and 2000 m. In the region of the Sargasso Sea the surface water is sinking down to form the North Atlantic Intermediate water, and it thus appears probable that this form, *minima*, may be carried downwards in this water mass and so enter the North Atlantic Intermediate Current.

At a somewhat deeper level in the Atlantic the f. *piseki* is to be found ; this form has been taken in the Benguela Current at 350–500 m. depth and in the Labrador Current at a depth of 750 m. ; in the Sargasso Sea it has been taken between 500 and 850 m., and hence it too is an inhabitant of the North Atlantic Intermediate water, but at a slightly deeper level than f. *minima*. Finally f. *maxima* is found in the water of the West Wind Drift at 500 m.

Similarly, *Pleuromamma abdominalis* (Lubb.) possesses several distinct forms that are, in all probability, associated with distinct water masses : thus f. *typica* occurs mainly in the upper stratum ; f. *edentata* occurs in the tropical region of the Indian Ocean at a depth of 520–1500 m., which suggests that it is an inhabitant of the Indian Intermediate Current, and below the Benguela Current in the South Atlantic Ocean at 1000 m. and so

in the Sub-polar Intermediate Current : Steuer's conclusion that its presence in this latter area is due to the Agulhas Current seems to be inadmissible. A third form, f. *abyssalis*, occurs in the West Wind Drift between 900 and 1500 m. depth, below the Benguela Current at 600–1000 m. depth and in the tropical region of the Indian Ocean at 520 m., so that it, too, appears to be an inhabitant of the South Polar Intermediate water. Below the Indian Equatorial Current at a depth of 800 m. we find a special sub-form, *thermophila*, which seems to be an inhabitant of the Indian intermediate water, and in the tropical belt of the Pacific Ocean the same sub-form occurs between 1000 and 4000 m., where it seems to be living in the Pacific intermediate water.

Provided the degree of isolation is sufficient and is continued for a sufficiently long time, such changes in size and structure may give rise to different species, and we may suppose that the ancestral forms of the genus *Rhincalanus* became adapted to life at different levels and in different current systems, and that, as a result of this isolation, three species were evolved, the smallest, *R. cornutus* (Dana), inhabiting the surface layer, the middle one, *R. nasutus* Giesbr., inhabiting the intermediate depths, and finally, the largest, *R. gigas* Brady, occurring only in the deepest levels.

In a number of species examples that have been taken at the same depth and in the same area appear to fall into groups according to their length measurements : in most of such cases two groups have been recorded, but in a few there have been three. In the majority of such instances there seems to be little or no difference in actual structure. In previous papers (Sewell, 1912, 1929, 1932 and 1940) I gave details of such groups in the following species from Indian waters and elsewhere :

Nannocalanus minor (Claus)
Undinula vulgaris (Dana).
Paracalanus aculeatus Giesbr.
Clausocalanus arcuicornis (Dana).
Lophothrix frontalis Giesbr.
Pleuromamma abdominalis (Lubb.).
Lucicutia flavicornis (Claus).
Oithona plumifera Baird.
O. setigera (Dana).
Euryte longicauda Philippi.
Harpacticus littoralis Sars.
Porcellidium fimbriatum Claus.
Eudactylopus opima (Brian).
Amphiascus calcarifer Sewell.
A. debilis Giesbr.
Teissierella knoxi Thomp. and A. Scott.
T. propinquua (T. Scott).
Ceyloniella armata (Claus).
Metis jusseaumei Richard.

Similar groups have been recorded in other species, some of which are surface-living forms, while others are from deeper levels :

Species.		Average length in mm. f. major.	f. minor.
Calocalanus styliremis Giesbr.	♀	0·92–0·95	0·65–0·74
Pseudocalanus elongatus Boeck	♀	1·9	1·63
	♂	1·44	1·36
Spinocalanus abyssalis Giesbr.	♀	1·45–1·60	0·95–1·08 (f. *pygmæa*)
(*vide* Farran, 1926, p. 242)	♂	1·80–2·06	1·18–1·20
Gætanus kruppi Giesbr.	♀	5·71	4·8–5·1
Scaphocalanus magnus (T. Scott)	♀	4·97	3·55
Heterorhabdus austrinus Giesbr.	♀	3·42–3·85	2·97–3·18
(*vide* Farran, 1929, p. 265)	♂	3·48–3·60	2·84–2·98

Augaptilus longicaudatus (Claus)	♀	3·5–4·3	4·5–5·9
Oithona nana Giesbr. (*vide* Gurney, 1927, p. 159)		0·62–0·69	0·53–0·55
Oncœa media Giesbr.	♀	0·74–0·82	0·58–0·65
	♂	0·63–0·68	0·54–0·62
O. venusta Philippi (*vide* Farran, 1929, p. 284)	♀	1·08–1·16	0·92–1·07 (var. *vanella*)
(present collection)	♀	1·10–1·26	0·80–0·95

Farran (1936) has described three such groups in *Oncœa conifera* Giesbr. ; these differ from one another in small anatomical details as well as in size, and he considers that form b is entitled to rank as a variety, which he terms var. *furcula.* The sizes of these three groups are as follows :

		Form a.	Form b.	Form c.
Oncœa conifera	♀	1·15–1·20	1·08–1·14	0·96–1·02 mm

The occurrence of such size groups at the same time and in the same locality is not confined to marine copepods, but has also been recorded in species that inhabit brackish- or fresh-water. T. Scott (1905*a*, p. 49) has recorded the presence of two such groups in the species *Eurytemora herdmani* Thomp. and A. Scott in the St. Lawrence River :

	Small form.	Large form.
♀	1·12 mm.	1·52 mm.
♂	1·14 „	1·61 „

and Gurney (1931) has recorded the same phenomenon in two species of the genus *Diaptomus* from fresh water :

		Small form.	Large form.
Diaptomus gracilis Sars	♀	0·99–1·2	1·4
	♂	0·98–1·17	1·26–1·35
Diaptomus wierzejskii Richard	♀	1·590	2·150
	♂	1·338	1·635

Different authors have attributed these groups to different causes : thus Störmer (1929), who found them off the west coast of Greenland, attributes them to a mixture of water of different origins, each having its own race of copepod, while Ottestad (1932), who recorded them from the Antarctic, attributes them to different broods, one having survived from the previous year. Marshall (1933), who found similar groups in *Calanus finmarchicus* (Gunn.) in the Clyde area, in water that appeared to be homogeneous, is inclined to think that they may have been different broods, a smaller surface-living brood and a larger deeper dwelling one, following the suggestion put forward by Russell (1928) that the small summer brood lives nearer the surface than the larger winter brood. Gurney (1931) attributes the occurrence of the two groups in *Diaptomus* to an extra moult from Stage VI to Stage VII, and he states that in the case of *Diaptomus laticeps* Sars " the range of size in Loch Hundland is so great that it seems necessary to suppose that in some cases there is a moult in the adult to a ' high form ' or Stage VII, which is not distinguished by structural change."

Coker (1934) has discussed the possible causes of the production of such groups, and he divides these into—

(1) The production of two forms at different stages in the life-history of the same individual. This he regards as very improbable among the Copepoda. I have however, in contrast, put this view forward as the explanation in several species that I have investigated (*vide* Sewell, 1914, 1929, 1932 and 1940), and Gurney (1931) has indicated that it is the explanation of the two forms of *Diaptomus wierzejskii* Rich. and *D. laticeps* Sars.

(2) The production in any given area of seasonal, e.g. winter and summer, forms. This phenomenon is termed " cyclomorphosis."

(3) The production of two or more forms by difference in the development of individuals from the same batch of ova. This Coker terms " true Dimorphism."

(4) The development of different races or varieties, which may occur—
- (a) simultaneously in different places ;
- (b) simultaneously in the same place ;
- (c) successively in the same or different places, one or both being dominant for part of the year.

In certain well-known species, such as *Calanus finmarchicus* (Gunn.) and *C. hyperboreus* Kröyer, size groups are known to occur, and have been attributed to differences, either seasonal or geographical, in the general hydrographic conditions : as regards seasonal changes it has been shown that in the North Atlantic *Calanus finmarchicus* (Gunn.) exhibits three generations a year, each generation giving rise to another that differs somewhat, and such a phenomenon falls into Coker's category (2), the phenomenon known as " cyclomorphosis." In the species noted above, however, the two forms have been taken in the same locality and at the same time, and therefore, presumably, must fall into Coker's category (3) or (4b). That the phenomenon is not a local one is indicated by the fact that in certain species this production of two size groups has been noted in different oceans. It is now recognized that there is a possibility that so-called " physiological " races may be developed within the limits of a single " morphological " species, as was suggested by Appellöf (1912), but such a development is correlated with different conditions in different habitats, and thus is comparable to the formation of geographical races. Runnstrom (1928) has, however, further suggested that these " physiological " races may have developed a different breeding season ; they could thus be taken in the same locality in the adult stage at different times of the year, or, if their length of life were sufficiently long and the two breeding seasons not too far apart, they might even overlap, and so be taken at the same time of the year and in the same locality in two different phases of adult life, viz. pre-breeding and post-breeding. Such an explanation, however, is improbable, since in the case of species that inhabit the warm surface water of the tropical and sub-tropical regions, the average span of life is almost certainly much shorter than in the colder waters of the temperate and boreal regions, where, as in the case of *Calanus finmarchicus* (Gunn.), there are only two or three generations in a year, and, furthermore, the temperature differences are relatively so small that they are, as noted above (*vide supra*, p. 369), insufficient to cause so clearly marked a difference in size. It seems to me that one is thus thrown back on the explanation that these two size groups in certain species may and probably do represent either successive stages in the life-history of a single individual, as in Coker's category (1), or else are the result of differences in

the development of individuals from the same brood, as in Coker's category (3), but, if the latter were the true explanation, one would certainly get similar size groups in the immature stages, and this does not appear to be the case, and in those instances in which two groups of the adult have been obtained, the size difference between the groups corresponds closely to what one would expect if the large form were obtained by an additional moult from the adult to the post-adult stage or Stage VI to Stage VII.

In yet other instances it is found that in different regions this difference in size is accompanied by small differences of structure and the two forms have been described as different species. Examples of this are :

Species.	Total length in mm. ♀.	♂.
Heterostylites longicornis (Claus)	2·50–3·50	..
H. major (Dahl)	4·40–5·00	..
Valdiviella ignota Sewell	6·5	..
V. insignis Farran	8·7	..
Chiridius nasutus	2·67–2·88	..
C. armatus Boeck	3·6–4·43	..
Heterorhabdus abyssalis (Giesbr.)	2·2–2·6	2·0–2·6
H. norvegicus (Boeck)	2·8–3·4	2·8–3·1
Cornucalanus chelifer (Thomp.)	6·0	..
C. magnus Wolfend.	7·8–8·0	6·0

and to these may perhaps be added :

Scolecithricella longicornis (T. Scott)	1·25	..
S. ctenopus (Giesbr.)	1·47	..
Euryte minor T. Scott	1·00	..
E. longicauda Philippi	1·30	..
Isochæta ovalis Giesbr.	1·34–1·50	1·22–1·32
Lucicutia frigida Wolfend.	1·50–1·60	..
L. flavicornis Claus	1·47–1·58	1·44–1·56
L. gemina Farran (*vide* Farran, 1926)	1·75–1·86	1·63–1·72
P. scotti Sewell	1·511	1·419
Pontellopsis macronyx A. Scott	1·733	..

Vervoort (1946) has given a list of several pairs of species which are probably growth classes of the same species, namely :

Pontellopsis herdmani Thompson and A. Scott and *P. macronyx* A. Scott.
Heterorhabdus abyssalis (Giesbr.) and *H. norvegicus* (Boeck).
Oithona challengeri Brady and *O. plumifera* Baird.
Gœtanus minor Farran and *G. minimus* Wolfenden.
Valdiviella insignis Farran and *V. ignota* Sewell.

It is possible that *Pontellopsis herdmani* Thompson and A. Scott, *P. macronyx* A. Scott and *P. scotti* Sewell, are all members of the same species.

In the genus *Pseudocalanus*, three so-called species, differing in size, have been recognized :

	♀	♂
Pseudocalanus elongatus Boeck	1·40 (average)	..
P. gracilis Sars	1·65 .	..
P. major Sars	2·40 .	..

With (1915, p. 66) suggests that some of the differences between these forms are congenital, while others may be attributable to differences of habitat.

In the genus *Clausocalanus* the matter appears to be still more complicated, for Farran (1926, p. 236) has recorded the occurrence of as many as four groups, to two of which he has given specific names :

	♀	♂
Clausocalanus paululus Farran	0·75–0·82 .	..
C. pergeus Farran	0·90–1·05 .	..
C. arcuicornis Claus f. *minor*	1·20–1·40 .	..
C. arcuicornis Claus f. *major*	1·40–1·60 .	..

In certain of the above instances the production of the two forms or " species " can be correlated with differences of habitat. Thus *Heterorhabdus norvegicus* (Boeck) is an arctic and North Atlantic form, inhabiting cold water, and has a distribution that extends southwards as far as lat. 29° N., whereas *H. abyssalis* Giesbr. appears to be an inhabitant of the South Polar intermediate current, its distribution extending from the region of the Cape of Good Hope northwards into the Atlantic Ocean as far as the west coast of Ireland and the Bay of Biscay, where Farran (1926) found that it showed a maximum concentration at a depth of 186–366 m. (100–200 fms.), as opposed to *H. norvegicus* (Boeck), that exhibited a maximum at 366–549 m. (200–300 fms.). As one would expect of an inhabitant of the South Polar intermediate current, *H. abyssalis* (Giesbr.) also extends northwards into the Indian Ocean as far as the Arabian Sea and the Gulf of Oman, where it was taken at a depth of some 400–650 m. The presence of two forms of the same species in different oceans, for instance, the one in the Atlantic and the other in the Indo-Pacific region, has been adduced as evidence in favour of the view that the Plankton of these two areas presents more or less specific differences. The data that Schmaus and Lehnhofer (1927) have given for the distribution of the species *Rhincalanus cornutus* (Dana) clearly indicates that individuals of the Indo-pacific form, f. *typica*, can at the present time be carried westward round the Cape of Good Hope into the region of the Benguela current and the Gulf of Guinea, and presumably when this transfer first took place, whether by this route or by any other such as the Tethys Sea in the Tertiary epoch, the change in conditions which the individuals experienced was accompanied by a change of structure in their offspring that gave rise to the f. *atlantica*, and it was this new form that was able to populate the Atlantic Ocean. If this be so, then it would appear that subsequent invaders of the f. *typica* have either been unable to establish themselves in face of the competition with the new form, f. *atlantica*, and so die out, or else their progeny has undergone exactly the same mutation. In the case of those closely related forms of the same species, such as we find in *Pleuromamma gracilis* (Claus) and *P. abdominalis* (Lubb.), that are to be found at different levels or in different parts of the same circulatory system in any one ocean, we

are faced with a different problem. Between such water masses as the Sub-polar and North Atlantic intermediate currents there lies a zone of admixture; thus examples of *P. gracilis* f. *maxima*, which apparently inhabits the West Wind Drift and thus can be carried northwards towards the tropics, may be transported across the boundary zone into the North Atlantic intermediate water, which appears to be the habitat of f. *piseki* (Farran), so that either f. *maxima* must die out or else its progeny must undergo transformation into f. *piseki*. Similarly, the various so-called "races" of *Acartia clausi* Giesbr., which are to be found in various parts of the North Atlantic circulatory system, cannot be regarded as definite biological entities; as we trace the North Atlantic Drift eastwards some of the water may be swept to the north-east and so reach the North Sea, while another mass may be swept to the south and so reach the Mediterranean Sea, and in all three regions we find the so-called "giant" race, but there is no break between the southerly branch of the North Atlantic Drift and the Canary Current, in which we find the so-called "dwarf" race, and it follows that specimens of the giant race that are carried southwards into the Canary Current will after one or more generations, depending on the length of time taken to transport examples from one region to the other, give rise to examples of the dwarf form, that will themselves be swept westward in the North Equatorial Current to the Carribean Sea and the east coast of North America, where they are to be found in the region of the Gulf Stream, and then continuing onwards into the North Atlantic Drift will again give rise to the "giant" form; and it seems probable that these two different forms are correlated with differences in the salinity and temperature of the water-mass in which they are living. If this be so, then it seems clear that such forms are examples of the phenomenon of "cyclomorphosis," similar to that found in *Calanus finmarchicus* (Gunn.), which possesses definite seasonal forms dependent on the temperature of the surface water.

It seems to me that the evidence that we have been studying indicates that the Copepods are extremely plastic, and that as we trace the distribution of any given species along the current system in which it is living, the parent form, when it reaches an area of different physical and chemical composition, may give rise to offspring that differ from the parent in size and even in structure, so that, perhaps not infrequently, the two forms have been described as different species. The presence of two such forms in different oceans must not therefore be taken to be evidence in favour of the specificity of the fauna of the two regions but rather as evidence of continuity, either at the present time or in the past, of distribution.

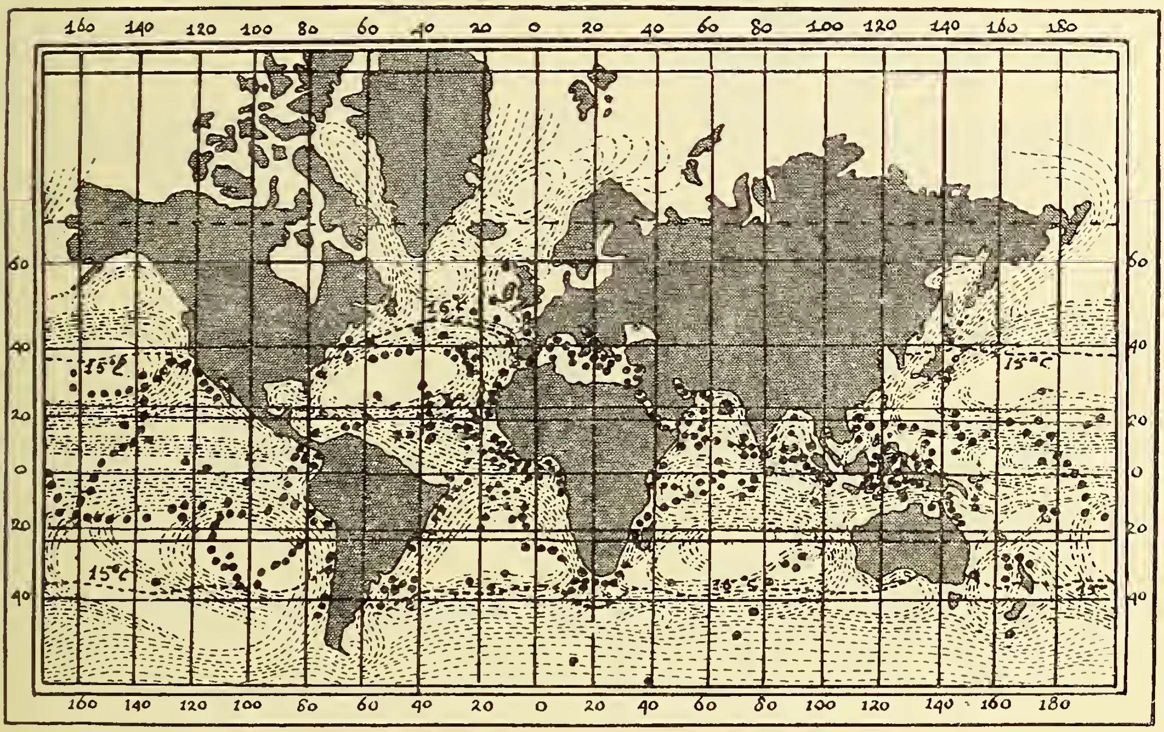
GEOGRAPHICAL DISTRIBUTION.

Although our knowledge of the distribution of many of the species is still incomplete, and it is probable that future researches, especially in the Pacific Ocean, will reveal the existence in that area of species that are yet unknown and of others that are at present known only from more western regions, it seems to me that we now know enough to justify one in attempting to trace the broad lines along which distribution has been carried out, and the degree to which this is dependent on the movement of the great water-masses of the oceans. It has been shown (*vide supra*, p. 327) that in the planktonic species there are two main groups that can be separated by the depth of their habitat, though a few are capable of surviving such wide changes of conditions that they may be taken in most areas and most depths: these two groups are (1) those that inhabit the upper levels and

are for the most part to be found in the upper 400–500 m., especially in the tropical and temperate regions, that is to say in that part of the ocean that Defant terms the " Troposphere," and (2) those that are usually to be found in greater depths, except in the subpolar and polar regions, where they may be taken at or near the surface, and that thus correspond to the mass of water that Defant terms the " Stratosphere." In order therefore to trace the distribution of these planktonic animals we must consider each group separately.

The Distribution of the Epi-Planktonic Species.

It is now well known that many of the epi-planktonic genera and species are to be found widely distributed throughout all the three great oceans. Lehnhofer (1926, p. 147, Text-fig. 20) has given a map, showing the distribution of the genus *Copilia* Dana, in the

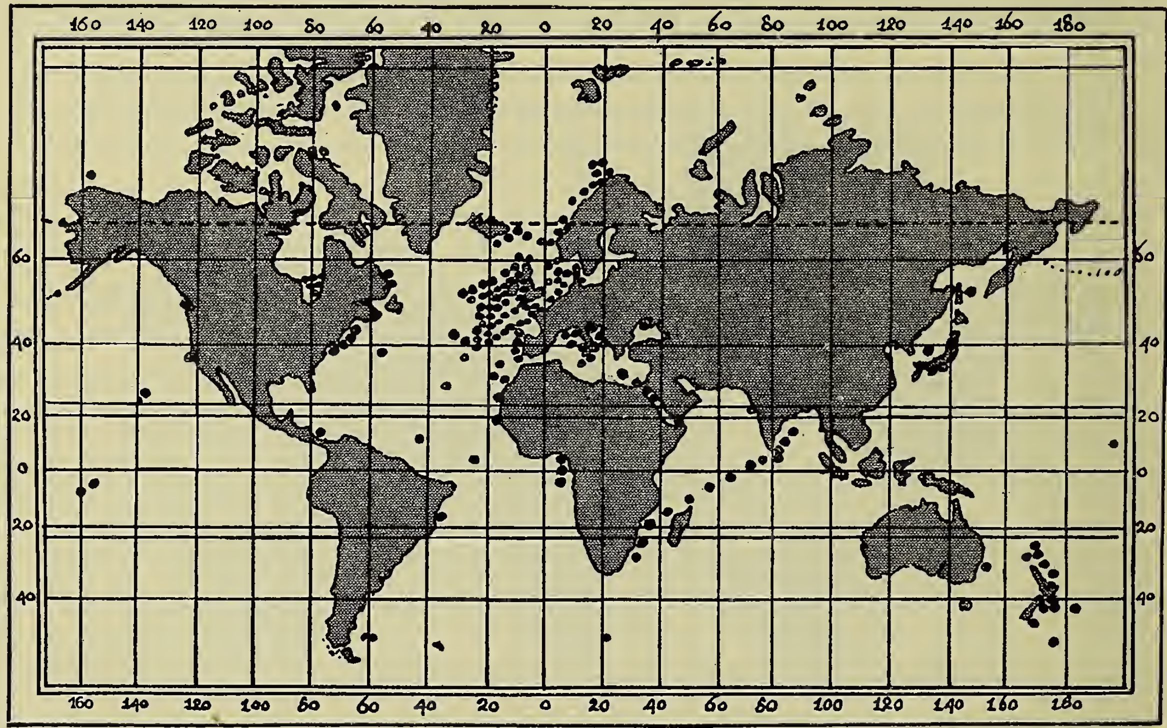


Text-fig. 83.—Sketch Chart showing the distribution of the genus *Sapphirina*, and the position of the 15° C. isotherm of the annual mean temperature of the surface-water.

Indian and Atlantic Oceans, and this clearly indicates how close is the agreement between the distribution and the general trend of the surface currents in this area ; and the same agreement can be traced in other genera. The same author (Lehnhofer, 1929), regarding the distribution of the genus *Sapphirina* J. V. Thompson, has stated that this is to be found for the most part in the circum-tropical belt, though, in comparison with the genus *Copilia*, the boundaries of their occurrence reach further towards the Arctic and Antarctic regions. In the accompanying map (Text-fig. 83) I have given the known present-day distribution of this genus, and from it it is clear that for the most part the range falls within the limits of the warm-water circulation of the tropical and temperate regions, though in a few instances species and individuals have been taken in higher latitudes in the Antarctic :

the close connection that exists between this genus and the pelagic Tunicata may possibly provide an explanation of this wider migration, but since the pelagic Tunicata are themselves dependent on the currents for their distribution, the relationship between the surface currents and the presence of the Sapphirinidæ is not affected.

In attempting to trace the dispersal of these planktonic forms it is essential that we should take a wide view of what constitutes a species. Furthermore, any explanation of such dispersal should also serve to explain the distribution of sub-species or closely related species, since, if these have evolved the one from the other or both from a common ancestor, they must at the commencement of the process of evolution have occupied the same or contiguous geographical areas, their subsequent separation being brought about either by



Text-fig. 84.—Sketch Chart showing the distribution of *Acartia clausi* Giesbr. (*sensu lato*).

being carried into different regions by the then existing currents, or by becoming separated at some later period by topographical changes. One must equally guard against the fatally easy process of rejecting all data that do not fit in with one's preconceived notions : for instance, when discussing the distribution of *Acartia clausi* Giesbr. Steuer (1923, p. 51), who regards this as a strictly Atlantic form, expresses astonishment that Thompson and A. Scott, when in 1903 they reported the presence of this species on the Ceylon Pearl Banks, were not struck with surprise, since according to Steuer this was the first report of its occurrence in the Indo-Pacific region. Steuer, however, has overlooked the fact that three years earlier, Thompson (1900) had recorded its presence from no fewer than 20 stations in the Indian Ocean, Arabian Sea and Red Sea ; and it hardly seems likely that this author, who had done so much work in the Atlantic Ocean, was not correct in his diagnosis. *Acartia clausi* (*vide* Text-fig. 84) has now been recorded from the North-

Pacific Ocean (Wilson), the west coast of North America (Esterly), the Alaskan coastal region (Willey), the south-west Pacific Ocean around New Zealand (Farran), the coast of New South Wales (Dakin and Colefax), the Indian Ocean, Ceylon Pearl Banks, Arabian Sea and Red Sea (Thompson, Thompson and A. Scott), the Gulf of Guinea and the Guinea Current (T. Scott, Rose), the tropical Atlantic (Farran), throughout the eastern North Atlantic region (Giesbrecht, Sars, Rose, Farran), throughout the Mediterranean Sea (Claus, Thompson, Thompson and A. Scott, Pesta, Car), and the Black Sea (Karawajew), off the coast of France (Canu), round the British Isles and in the English Channel (Thompson, Norman and T. Scott, Farran, Pearson), in the North Sea (Gurney), Kiel Bay (Canu, Kunz), off the coast of Norway (Sars), in the Arctic Ocean (Mrazek), off Labrador (Jespersen), in Hudson Bay (Willey), and off the east coast of North America (Williams, Wilson, Bigelow, Fish). Two other so-called species that are very closely related to, if not actually identical with, *Acartia clausi*, namely *A. simplex* Sars and *A. ensifera* Brady, have been recorded from the south-west Pacific region ; and Farran (1929) regards the latter as a synonym of *A. clausi*. Certainly all three forms are very closely related, and it seems to be merely a matter of individual opinion whether they are regarded as forms of a single widespread species, which exhibits slight local variations, as one might expect, in widely separate localities such as the variety, var. *gaboonensis* T. Scott, from the Guinea Current and the Gulf of Guinea, and the sub-species *A. clausi hudsonica* Pinney from Hudson Bay, or, alternatively, as three very closely related species that have evolved in different localities from a single widely-dispersed ancestor : personally I prefer the former view and, judged from this standpoint, it seems clear that far from being an Atlantic form, *Acartia clausi* (*sensu lato*) is a species of world-wide distribution.

In order to be able to form a general idea regarding the mode and direction of distribution of such planktonic forms it is essential that we should reach a conclusion regarding their source of origin. Steuer (1933, p. 275) claims that " Die Südhalbkugel ist der Ausbildung von ozeanischen Formen, die küstenreiche Nordhalbkugel der Entwicklung neritischer Formen günstig." That the majority of the so-called oceanic species are found to be living in the southern hemisphere is due solely to the geographical distribution of land and sea, the southern hemisphere being almost entirely oceanic. The assumption that these oceanic species originated in the southern hemisphere is entirely unwarranted. Similarly, so-called " neritic " species may have originated along any stretch of coast, especially in regions where there is a change in local conditions. In tropical regions, where large rivers open into the ocean, a number of species, that may be called neritic, appear to have had their origin, but many of these exhibit a marked tendency to invade brackish water and even to penetrate upstream, so that they ultimately become inhabitants of fresh water, rather than pass seawards and take up their habitat in the open ocean. One region that appears to have been extremely prolific in the production of new species of this type is the Malay Archipelago and the neighbouring region of the Bay of Bengal, others are the east coast of South America and the south and south-east coast of Australia and New Zealand. Steuer (1933) has also pointed out that a number of Atlantic genera and sub-genera are represented in the Indo-Pacific region, and that in such instances the Indo-Pacific species are found to be the more primitive. Burckhardt (1913), several years earlier, pointed out that in the genus *Oithona* a large number of species are known from the Atlantic Ocean, but that these all belong to only two of the various groups into which the genus can be divided, whereas from the Pacific Ocean we know of many species

among which are representatives of all these various groups ; and he therefore concludes that the genus has radiated from the Pacific Ocean. During Tertiary times, when there was a direct connection by means of the Tethys Sea between the Pacific and Atlantic Oceans and another one across Central America between the Atlantic and Pacific, warm-water epi-planktonic species might have arisen in any part of the system and have rapidly become cosmopolitan, but with the closure of the Tethys and the upheaval of Central America such species will have found it difficult to pass from the Indo-Pacific area to the Atlantic and impossible to get from the Atlantic to the Pacific. As I have previously pointed out (Sewell, 1929, p. 4), " such differences as do occur in the copepodid fauna of the two regions (Atlantic and Pacific) are to be attributed to the occurrence in the Atlantic Ocean of an indigenous fauna that has been evolved in that region and, owing to the total absence of any connecting passages between the tropical and temperate regions of this ocean and the Pacific or Indian Oceans, for as a possible route for the dispersal of planktonic marine organisms the Panama Canal can be ignored, these indigenous forms are completely unable to extend their habitat." It thus seems to me that such evidence as we now possess points to the Pacific Ocean as being the original place of origin of the warm-water epi-planktonic Copepoda.

Thanks to the work of Dana (1847–49), Giesbrecht (1892), Esterly (1905, 1924), Campbell (1929), Johnson (1938) and Wilson (1942), we now have records of 184 epi-planktonic Copepoda from the East Pacific region, namely :

Calanus cristatus Kröyer.
C. finmarchicus (Gunn.).
C. hyperboreus Kröyer.
? *C. propinquus* Brady.
C. tonsus Brady.
Nannocalanus minor (Claus).
Canthocalanus pauper (Giesbr.).
Undinula caroli (Giesbr.).
U. darwini (Lubb.).
U. vulgaris (Dana).
Eucalanus bungii bungii Giesbr.
E. bungii californicus Johnson.
E. crassus Giesbr.
E. monachus Giesbr.
E. mucronatus Giesbr.
E. pileatus Giesbr.
E. subcrassus Giesbr.
E. subtenuis Giesbr.
Rhincalanus cornutus f. *typica* Dana.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. parvus (Claus).
Acrocalanus gibber Giesbr.
A. gracilis Giesbr.
A. longicornis Giesbr.

A. monachus Giesbr.
Calocalanus pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Drepanopus forcipatus Giesbr.
Pseudocalanus minutus Kröyer (= *elongatus* (Boeck)).
Microcalanus pusillus Sars (? = *pygmæus* Sars).
M. pygmæus Sars.
Ctenocalanus vanus Giesbr.
Euchæta acuta Giesbr.
E. flava Giesbr.
E. grandiremis Giesbr.
E. japonica Marukawa.
E. longicornis Giesbr.
E. marina (Prestand.).
E. media Giesbr.
E. philippi Brady.
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).
S. minor (Brady).
S. porrecta (Giesbr.).
Centropages brachiatus (Dana).
C. bradyi Wheeler (= *violaceus* Brady, pars).
C. calaninus (Dana).
C. elegans Giesbr.
C. elongatus Giesbr.
C. furcatus (Dana).
C. gracilis (Dana).
C. mcmurrichi Willey.
Pseudodiaptomus (*Pseudodiaptalloas*) *euryhyalinus* Johnson.
Eurytemora hirundoides (Nordquist).
E. johanseni Willey.
E. transversalis Campbell.
Temora discaudata Giesbr.
T. stylifera (Dana).
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bipinnata Giesbr.
C. bispinosa Claus.
C. catula Giesbr.
C. columbiæ Campbell.
C. curta Dana.
C. pachydactyla Dana.
C. pectinata Brady (= *armata* Boeck).

C. simplex Giesbr.
C. truncata Dana.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
L. jollæ Esterly.
L. lubbocki Giesbr.
L. trispinosa Esterly.
Paralabidocera amphitrites McMurrich.
Pontella agassizi Giesbr.
P. atlantica (M. E.).
P. danæ Giesbr.
P. fera Dana.
P. lobiancoi (Canu).
P. princeps Dana.
P. securifer Brady.
P. tenuiremis Giesbr.
Anomalocera patersoni Templ.
Pontellopsis lubbocki (Giesbr.).
P. occidentalis Esterly.
P. regalis (Dana).
Pontellina plumata Dana.
Acartia clausi Giesbr.
A. danæ Giesbr.
A. denticornis Brady.
A. laxa Dana.
A. lilljeborgi Giesbr.
A. longiremis (Lillj.).
A. negligens Dana.
A. tonsa Dana.
Tortanus discaudatus (Thomp. and A. Scott).
T. forcipatus (Giesbr.).
Oithona atlantica Farran (= *spinirostris* Claus).
O. attenuata Farran.
O. brevicornis Giesbr.
O. hebes Giesbr.
O. linearis Giesbr.
O. nana Giesbr.
O. plumifera Baird.
O. setigera (Dana).
O. similis Claus (= *helgolandica* Sars).
Oncæa anglica Brady.
O. borealis Sars.
O. conifera Giesbr.
O. curta Sars.
O. dentipes Giesbr.

O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
O. notopus Giesbr.
O. ornata Giesbr.
O. similis Sars.
O. subtilis Giesbr.
O. tenella Sars.
O. tenuimana Giesbr.
O. venusta Philippi.
Conea rapax Giesbr.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus (*Corycæus*) *clausi* F. Dahl.
C. (*C.*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.
C. (*C.*) *vitreus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *furcifer* Claus.
C. (*U.*) *lautus* Dana.
C. (*U.*) *longistylis* Dana.
C. (*Ditrichocorycæus*) *africanus* F. Dahl.
? *C.* (*D.*) *anglicus* Lubb.
C. (*D.*) *andrewsi* Farran.
C. (*D.*) *tenuis* Giesbr.
C. (*Onychocorycæus*) *agilis* Dana (= *gracillicaudatus* Giesbr.).
C. (*O.*) *catus* F. Dahl.
C. (*O.*) *giesbrechti* F. Dahl.
C. (*O.*) *ovalis* Claus.
C. (*O.*) *obtusus* Dana.
C. (*O.*) *pumilus* M. Dahl.
C. (*O.*) *pacificus* F. Dahl.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *concinnus* Dana.
C. (*C.*) *curtus* Farran.
C. (*C.*) *gibbulus* Giesbr.
? *C.* (*C.*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. bicuspidata Giesbr.
S. iris Dana (= *longifurca* A. Scott).
S. metallina Dana.

S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
S. stellata Giesbr.
Copilia lata Giesbr.
C. mediterranea (Claus) (= *denticulata* Claus).
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea (Haeckel).
? *Pontoeciella abyssicola* (T. Scott).
Vettoria granulosa (Giesbr.) (= *Corina granulosa*)
Pachysoma tuberosum Giesbr.
P. punctatum Claus.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Miracia efferata Dana.
Macrosetella gracilis (Dana).
M. oculata Sars.
Clytemnestra scutellata Dana.
C. rostrata (Brady).
Ægisthus aculeatus Giesbr.
A. mucronatus Giesbr.
? *A. spinulatus* Farran.

In the Pacific Ocean there is a considerable difference in the facility with which warm-water species can be carried from the tropical region of the American coast westwards to the Asiatic coast in the north and south equatorial currents on the one hand, and in the opposite direction from the western tropical and sub-tropical regions eastward to the coasts of North and South America respectively. Throughout the tropical belt lie the wide north and south equatorial currents running from east to west, and though between them lies the warm contra-equatorial current, the extent of this is considerably less (*vide* Chart I). In the northern hemisphere there is a continuous current system flowing eastward that is formed by the Kuro-Siwo current, the North Pacific Drift and the California current off the west coast of North America, but this stream passes far to the north and gradually becomes cooled, so that the last part of the great circular movement, the California Current, is a cool one. In the southern hemisphere the difficulty of passing from west to east is even greater, for the warm East Australian Current, that swings eastward past New Zealand, runs in close apposition to the West Wind Drift, and finally this latter current sends a large branch that turns northwards and runs along the South American coast, where it is known as the Humbolt Current: this last mass of water is a cold one and carries with it a sub-antarctic fauna. In conformity with these differences in the local conditions on the western side of North and South America, it is found that there are marked differences in the Copepod fauna of the two regions. Esterly (1905, 1924), McMurrich (1916) and Campbell (1929) recorded 50 species from the west coast of North

America between the Tropic of Cancer and lat. 50° N., and Dana (1847–49) and Giesbrecht (1892) provided records of 42 species that have been taken off the west coast of South America south of lat. 10° S. and thus in the region of the Humbolt Current. I give below a list of the species that are now known to be present in these two, north and south, regions of the East Pacific, our knowledge of which has recently been greatly augmented by Wilson (1942), who has reported on the collections made by the " Carnegie " :

Species from the W. coast of North America between lats. 23°–50° N.	Species from the W. coast of South America between lats. 10°–50° S.
Calanus cristatus Kröyer.	..
C. finmarchicus (Gunn.).	..
C. hyperboreus Kröyer.	..
? *C. propinquus* Brady.	..
C. tonsus Brady.	*Calanus tonsus* Brady.
Canthocalanus pauper (Giesbr.).	*Canthocalanus pauper* (Giesbr.).
Nannocalanus minor (Claus).	*Nannocalanus minor* (Claus).
..	*Undinula caroli* (Giesbr.) (= *U. darwini*, (Lubb.)).
Undinula darwini (Lubb.).	*U. darwini* (Lubb.).
U. vulgaris (Dana).	*U. vulgaris* (Dana).
Eucalanus bungii Giesbrecht.	..
E. bungii californicus Johnson.	..
E. crassus Giesbr.	*Eucalanus crassus* Giesbr.
E. monachus Giesbr.	*E. monachus* Giesbr.
E. mucronatus Giesbr.	..
..	*E. pileatus* Giesbr.
..	*E. subcrassus* Giesbr.
E. subtenuis Giesbr.	..
..	*Rhincalanus cornutus* f. *typica* Dana.
Mecynocera clausi Thompson.	*Mecynocera clausi* Thompson.
Paracalanus aculeatus Giesbr.	*Paracalanus aculeatus* Giesbr.
P. parvus (Claus).	*P. parvus* (Claus).
? *P. pygmæus* Claus.	..
Acrocalanus gibber Giesbr.	..
A. gracilis Giesbr.	*Acrocalanus gracilis* Giesbr.
A. longicornis Giesbr.	*A. longicornis* Giesbr.
A. monachus Giesbr.	..
Calocalanus pavo (Dana).	*Calocalanus pavo* (Dana).
C. plumulosus (Claus).	*C. plumulosus* (Claus).
C. styliremis Giesbr.	*C. styliremis* Giesbr.
Clausocalanus arcuicornis (Dana).	*Clausocalanus arcuicornis* (Dana).
C. furcatus (Brady).	*C. furcatus* (Brady).
Ctenocalanus vanus Giesbr.	..
Pseudocalanus minutus Kröyer.	*Pseudocalanus minutus* Kröyer.
Microcalanus pusillus Sars.	*Microcalanus pusillus* Sars.
M. pygmæus Sars.	*M. pygmæus* Sars.

Species from the W. coast of North America between lats. 23°–50° N.	Species from the W. coast of South America between lats. 10°–50° S.
..	*Drepanopus forcipatus* Giesbr.
Euchæta acuta Giesbr.	*Euchæta acuta* Giesbr.
E. marina (Prestand.).	*E. marina* (Prestand.).
Scolecithrix danæ (Lubb.).	*Scolecithrix danæ* (Lubb.).
Scolecithricella bradyi (Giesbr.).	*Scolecithricella bradyi* (Giesbr.).
..	*S. minor* (Brady).
..	*Centropages brachiatus* (Dana).
Centropages bradyi Wheeler.	..
C. calaninus (Dana).	*C. calaninus* (Dana).
C. elongatus Giesbr.	*C. elongatus* Giesbr.
..	*C. furcatus* (Dana).
C. hamatus (Lillj.).	..
C. mcmurrichi Willey.	..
..	*Temora discaudata* Giesbr.
..	*T. stylifera* (Dana).
Pseudodiaptomus (*Pseudodiaptallous*) *euryhyalinus* Johnson.	..
Eurytemora hyrundoides (Nordquist).	..
E. johanseni Willey.	..
E. transversalis Campbell (= *americana* Williams).	..
..	*Lucicutia flavicornis* (Claus).
Candacia æthiopica Dana.	*Candacia æthiopica* Dana.
C. bipinnata Giesbr.	*C. bipinnata* Giesbr.
C. bispinosa Claus.	*C. bispinosa* Claus.
C. columbiæ Campbell.	..
C. curta Dana.	*C. curta* Dana.
C. pectinata Brady.	..
C. simplex Giesbr.	*C. simplex* Giesbr.
C. truncata Dana.	*C. truncata* Dana.
..	*Labidocera acuta* (Dana).
Labidocera acutifrons (Dana).	*L. acutifrons* (Dana).
L. detruncata (Dana).	*L. detruncata* (Dana).
L. jollæ Esterly.	..
L. lubbocki Giesbr.	..
L. trispinosa Esterly.	..
Paralabidocera amphitrites McMurrich.	..
Pontella atlantica (M. E.)	*Pontella atlantica* (M. E.).
..	*P. danæ* Giesbr.
..	*P. fera* Dana.
P. lobiancoi Giesbr.	..
..	*P. princeps* Dana.
P. securifer Brady.	*P. securifer* Brady.

Species from the W. coast of North America between lats. 23°–50° N.	Species from the W. coast of South America between lats. 10°–50° S.
P. tenuiremis Giesbr.	*P. tenuiremis* Giesbr.
Anomalocera patersoni Templ.	..
Pontellopsis occidentalis Esterly.	..
..	*Pontellopsis regalis* (Dana).
Pontellina plumata Dana.	*Pontellina plumata* Dana.
Acartia clausi Giesbr.	..
A. danæ Giesbr.	*Acartia danæ* Giesbr.
..	*A. denticornis* Brady.
..	*A. lilljeborgi* Giesbr.
A. longiremis (Lillj.).	..
A. negligens Dana.	*A. negligens* Dana.
Tortanus discaudatus (Thomp. and A. Scott).	..
Oithona atlantica Farran.	*Oithona atlantica* Farran.
..	*O. attenuata* Farran.
O. brevicornis Giesbr.	*O. brevicornis* Giesbr.
O. nana Giesbr.	*O. nana* Giesbr.
O. plumifera Baird.	*O. plumifera* Baird.
O. similis Claus.	*O. similis* Claus.
Oncæa borealis Sars.	..
O. conifera Giesbr.	..
..	*Oncæa curta* Sars.
..	*O. curvata* Giesbr.
..	*O. dentipes* Giesbr.
O. media Giesbr.	*O. media* Giesbr.
..	*O. mediterranea* Claus.
O. minuta Giesbr.	*O. minuta* Giesbr.
..	*O. notopus* Giesbr.
..	*O. similis* Sars.
O. subtilis Giesbr.	*O. subtilis* Giesbr.
..	*O. tenella* Sars.
O. venusta Philippi.	*O. venusta* Philippi.
Lubbockia aculeata Giesbr.	*Lubbockia aculeata* Giesbr.
L. squillimana Claus.	*L. squillimana* Claus.
Corycæus agilis Dana.	*Corycæus agilis* Dana.
..	*C. andrewesi* Farran.
C. anglicus Lubb.	..
C. catus F. Dahl.	*C. catus* F. Dahl.
C. clausi F. Dahl.	*C. clausi* F. Dahl.
C. crassiusculus Dana.	*C. crassiusculus* Dana.
C. flaccus Giesbr.	*C. flaccus* Giesbr.
C. furcifer Claus.	*C. furcifer* Claus.
..	*C. giesbrechti* F. Dahl.

Species from the W. coast of North America between lats. 23°–50° N.	Species from the W. coast of South America between lats. 10°–50° S.
C. gracillicauda Giesbr.	*C. gracillicauda* Giesbr.
C. lautus Dana.	*C. lautus* Dana.
C. limbatus Brady.	*C. limbatus* Brady.
C. longistylis Dana.	*C. longistylis* Dana.
C. obtusus Dana.	*C. obtusus* Dana.
C. ovalis Claus.	*C. ovalis* Claus.
..	*C. pacificus* F. Dahl.
C. pumilus M. Dahl.	*C. pumilus* M. Dahl.
C. robustus Giesbr.	*C. robustus* Giesbr.
C. speciosus Dana.	*C. speciosus* Dana.
C. typicus Kröyer.	*C. typicus* Kröyer.
C. (*Corycella*) *carinatus* Giesbr.	*C.* (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *concinnus* Dana.	*C.* (*C.*) *concinnus* Dana.
..	*C.* (C.) *curtus* Farran.
C. (C.) *gibbulus* Giesbr.	*C.* (C.) *gibbulus* Giesbr.
..	*C.* (C.) *gracilis* Dana.
C. (C.) *rostratus* Claus.	*C.* (C.) *rostratus* Claus.
Sapphirina angusta Dana.	*Sapphirina angusta* Dana.
S. auronitens Claus—*sinuicauda* Brady.	*S. auronitens* Claus—*sinuicauda* Brady.
S. iris Dana.	*S. iris* Dana.
S. metallina Dana.	..
S. nigromaculata Claus.	*S. nigromaculata* Claus.
S. opalina Dana—*darwini* Haeckel.	*S. opalina* Dana—*darwini* Haeckel.
S. scarlata Giesbr.	..
Copilia mediterranea (Claus).	*Copilia mediterranea* (Claus).
..	*C. quadrata* Dana.
? *Pontoeciella abyssicola* (T. Scott).*	..
Vettoria granulosa (Giesbr.).	*Vettoria granulosa* (Giesbr.).
Pachysoma punctatum Claus.	*Pachysoma punctatum* Claus.
P. tuberosum Giesbr.	..
Microsetella norvegica (Boeck).	*Microsetella norvegica* (Boeck).
M. rosea Dana.	*M. rosea* Dana.
..	*Euterpina acutifrons* (Dana).

* Wilson (1942) has described two new genera, each containing a single species, namely, *Carnegiella gracilis* and *Danodes plumata*; in each case he states that he had examples of the female only. A comparison of Wilson's description and figures of *Carnegiella gracilis* (Wilson, 1942, p. 176, figs. 20–25) with those given by T. Scott (1894. p. 129, pl. xii, figs. 5–9) and Farran (1936, p. 125, figs. 24 d and e) of the male of *Pontoeciella abyssicola* T. Scott reveals such a high degree of similarity that I have no doubt that Wilson had before him a male of a species of *Pontœciella* and probably a specimen of *P. abyssicola.* Similarly Wilson's description and figures of the female of *Danodes plumata* (Wilson, 1942, p. 182, figs. 57–68) show a close agreement with the female of *Pontœciella abyssicola* T. Scott, as described by T. Scott (1894, p. 128, pl. xiv, figs. 11–18) and by Giesbrecht (1899, p. 20, pl. v, figs. 15–27). It thus seems highly probable that Wilson had before him examples of both sexes of a species of *Pontœciella*, possibly *P. abyssicola*, and, if this be the case, the two genera *Carnegiella* and *Danodes* must be relegated to the list of synonyms of *Pontœciella.*

Species from the W. coast of North America between lats. 23°–50° N.	Species from the W. coast of South America between lats. 10°–50° S.
Macrosetella gracilis (Dana).	*Macrosetella gracilis* (Dana).
..	*M. oculata* Sars.
Miracia efferata Dana.	..
Clytemnesta rostrata (Brady).	*Clytemnestra rostrata* (Brady).
C. scutellata Dana.	*C. scutellata* Dana.

Some of the above records are open to doubt. The presence of *Calanus propinquus* Brady, which is an Antarctic form, in the upper stratum of the North Pacific Ocean seems highly improbable. Wilson's (1942) record of the occurrence of *Paracalanus pygmæus* (Claus) also appears to be doubtful: this species was most imperfectly described by Claus (1936), and the main feature by which he separated the species from others of the genus, namely the presence of three segments in the 5th leg of the female, is known to occur as an abnormality in both *Paracalanus aculeatus* (*vide* Sewell, 1929) and *P. parvus* (*vide* Norman and T. Scott, 1906). As regards yet another species, *Corycæus obtusus* Dana, M. Dahl (1912) holds that several species have been confused under this name; thus the specific identity of the forms from the north and south regions of the west coast of America must remain in doubt.

Of the 115 species recorded from the northern region, four are as yet unknown from elsewhere and are in all probability endemic; these are:

Candacia columbiæ Campbell.
Pontellopsis occidentalis Esterly.
Labidocera jollæ Esterly.
Pontella lobiancoi Giesbr.

A number of species have been recorded from the Arctic regions by T. Scott (1899), Sars (1900 and 1909), T. and A. Scott (1901), Mrazek (1902), Willey (1920 and 1932), and Jespersen (1923, 1934, 1937 and 1939), and several of these appear to have been swept southwards and have been taken in the northern part of the Pacific Ocean. Graham (1943) has pointed out that at one of the "Carnegie" Stations in the North Pacific (Sta. 122) there was an admixture of cold water of low salinity that had come in from the Bering Sea, and Wilson (1942) reports that at this station the following 21 species of Copepoda were captured:

Acrocalanus gracilis Giesbr.
**Calanus cristatus* Kröyer.
**C. finmarchicus* (Gunn.).
**C. hyperboreus* Kröyer.
Clausocalanus arcuicornis (Dana).
Eucalanus attenuatus (Dana).
E. elongatus (Dana).
Euchæta acuta Giesbr.
**Gaidius tenuispinus* Sars.
**Metridia longa* (Lubb.).
M. lucens Boeck.

Microsetella rosea Dana.
Neocalanus gracilis (Dana).
N. robustior Giesbr.
**Oithona similis* Claus.
Oncœa minuta Giesbr.
Paracalanus parvus (Claus).
P. pygmæus (Claus).
**Pseudocalanus minutus* Kröyer.
Scolecithricella bradyi (Giesbr.).
S. porrecta (Giesbr.).

Of the above species at least seven, marked with an asterisk, are known to be inhabitants of Arctic waters, and there seems to be little doubt that these have been swept southwards through the Bering Sea. A number of these and other species, that are known from the Arctic region, have been taken in the north Pacific area in the surface stratum and the full list is as follows :

Calanus cristatus Kröyer.
C. finmarchicus (Gunn.).
C. hyperboreus Kröyer.
C. tonsus Brady.
Ctenocalanus vanus Giesbr.
Pseudocalanus elongatus (Boeck) (= *minutus* Kröyer and *gracilis* Sars).
Microcalanus pusillus Sars.
M. pygmæus Sars.
Centropages hamatus (Lillj.).
C. mcmurrichi Willey.
Eurytemora americana Williams.
E. hyrundoides (Nordquist).
E. johanseni Willey.
Anomalocera patersoni Templ.
Paralabidocera amphitrites McMurrich.
Tortanus discaudatus Thomp. and A. Scott.
Acartia clausi Giesbr.
A. longiremis (Lillj.).
Oithona similis Claus.
O. spinirostris Claus (= *attenuata* Farran).
Oncœa borealis Sars.

Some of the above species appear to have been able to penetrate further to the south than others ; thus

Calanus tonsus Brady,
Pseudocalanus elongatus (Boeck),
Microcalanus pusillus Sars,
Centropages hamatus (Lillj.),
C. mcmurrichi Willey,
Eurytemora americana Williams (as *E. transversalis* Campbell),
Oithona similis Claus,

O. spinirostris Claus,
Acartia longiremis (Lilli.),
Oncæa borealis Sars,

have been recorded from the region of Vancouver Island, while

Calanus finmarchicus (Gunn.),
Paralabidocera amphitrites McMurrich,
Eurytemora hirundoides (Nordquist),
Acartia clausi Giesbr.,
Tortanus discaudatus Thomp. and A. Scott,

have got as far as the San Francisco region. Willey (1920, p. 45) has remarked, " there is an inexhaustible supply of this fish food in the Arctic Ocean, whence it filters down into the Northern Seas." In this region it is, however, difficult to correlate this southward movement of the surface plankton with the general drift of the surface-water. Recent work in the Arctic Ocean and the Bering Sea seems to indicate that there is, at least in the main, a northward drift : Thompson, Zeusler and Goodman (1940) state that there is a general northward movement of the waters from the Pacific Ocean into the Bering Sea through the passes formed by the Aleutian Islands, and in the western part of the Bering Strait between St. Lawrence Island and the Asiatic coast there seems to be a northerly movement of the water at all times of the year. The same observers (*vide* Goodman, Thompson and Zensler, 1940) indicate that on the east side of the Bering Strait off the American coast there is also a northward movement of the surface-water past Kotzebue Sound towards Point Barrow. Only on the extreme west side of Bering Strait Siberian Arctic water appears to move somewhat towards the south, where it forms the Oya-shio current, and produces a variable eddy. It would thus appear probable that the southward movement of the arctic plankton into the north Pacific area must be brought about by movement of this water in the Oya-shio Current.

This southerly drift from the Arctic Ocean into the north-western region of the Pacific Ocean seems to account for the occurrence of the following species round Japan :

Calanus cristatus Kröyer.
C. finmarchicus (Gunn.).
Pseudocalanus elongatus (Boeck).
Ctenocalanus vanus Giesbr.
Eurytemora pacifica Sato (? = *johanseni* Willey).
Centropages hamatus (Lillj.)*
Anomalocera patersoni Templ.
Acartia clausi Giesbr.†
A. longiremis (Lillj.).
Oithona similis Claus.
Microsetella norvegica Boeck.

* It is possible that this record should be *Centropages mcmurrichi* Willey. McMurrich (1919) in his record of the occurrence of this species gave it under the name *C. hamatus* (Lillj.), though he noted that there were certain small differences in his specimens, and Willey (1920) created the new species *C. mcmurrichi* to accommodate these examples and others that he obtained off Alaska.

† This species was originally recorded by Marukawa (1921) under the name *Acartia bifilosa* Giesbr.; but Steuer (1933) has pointed out that the record in all probability refers to *A. clausi* Giesbr.

All these species have probably been carried southwards by the Oya-shio Current, especially in the winter months (*vide* Schott, 1935, Pl. XXIX), and may then have been caught up in the North Pacific Drift and so have been swept eastwards towards the American Coast. Recent work off the Californian coast (*vide* Thompson and Goodman (1940), and Fleming (1940)), has indicated that between the Californian Current and the coast there is commonly a flow to the north, termed the Californian counter-current, that can be traced between lats. 25° and 45° N. ; but during the spring this current may disappear on the surface and upwelling takes place from about 200 m. depth ; below 200 m. the counter current still persists. Species may thus be caught up in the counter-clockwise movement of the Alaska Current, and be swept first westward around the coast of Alaska and then northwards through the Bering Strait to the Arctic Ocean. Steuer (1933, p. 280) has suggested that both *Tortanus discaudatus* Thompson and A. Scott in the northern hemisphere and *Acartia lilljeborgi* Giesbr. in the southern hemisphere are coastal forms that in the Tertiary epoch inhabited the Atlantic and Indo-Pacific Oceans before the Isthmus of Panama was formed and cut off the connection between the two oceans, and that since then *Tortanus discaudatus* has migrated northwards towards the pole on both sides of the North American continent, so that to-day it is a boreal-atlantic and boreal pacific form ; *Acartia lilljeborgi* on the other hand he supposes to have migrated southwards on both sides of the South American continent. It seems much more probable, so far as *Tortanus discaudatus* is concerned, that this species is a boreal-arctic form, and like *Eurytemora hyrundoides* (Nordquist) has been swept southwards from the Arctic Ocean through the Bering Strait to the west coast of North America and by the Labrador Current through Baffin Bay and Davis Strait to the Gulf of St. Lawrence and Puget Sound, where it was originally discovered.

Turning now to the species that have been recorded from the west coast of South America and the adjoining area of the South Pacific Ocean, we find that out of a total of 111 species, 94, or 85 per cent., are known from the tropical and south-western regions of the Pacific, and yet as many as 35 species have not so far been recorded from the north-eastern area, namely :

Undinula caroli (Giesbr.).*
Eucalanus pileatus Giesbr.
E. subcrassus Giesbr.
Drepanopus forcipatus Giesbr.
Rhincalanus cornutus Dana.
Scolecithricella minor (Brady).
Centropages brachiatus (Dana).
C. furcatus (Dana).
Temora discaudata Giesbr.
T. stylifera (Dana).
Lucicutia flavicornis (Claus).
Labidocera acuta (Dana).
Pontella danæ Giesbr.
P. fera Dana.

* As I have previously pointed out, this " species " is in my opinion a variety of *Undinula darwini* (*vide* Sewell, 1929, p. 46).

P. princeps Dana.
Pontellopsis regalis (Dana).
Acartia denticornis Brady.
A. lilljeborgi Giesbr.
Oithona attenuata Farran.
Oncæa curta Sars.
O. curvata Giesbr.
O. dentipes Giesbr.
O. mediterranea Claus.
O. notopus Giesbr.
O. similis Sars.
O. tenella Sars.
O. venusta Philippi.
Corycæus andrewesi Farran.
C. giesbrechti F. Dahl.
C. pacificus F. Dahl (? = *obtusus* Dana).
C. (*Corycella*) *curtus* Farran.
C. (*C.*) *gracilis* Dana.
Copilia quadrata Dana.
Euterpina acutifrons (Dana).
Macrosetella oculata Sars.

Of the above species 23 are known to occur in the south-west region of the Pacific, and possibly a twenty-fourth, *Corycæus* (*Corycella*) *gracilis*, is to be found there, though the record of this is doubtful : 23 species occur in the Indian Ocean and 24 in the Atlantic. It is thus clear that many of them are hardy species, capable of surviving considerable changes in the character of their habitat ; and this is especially true of those species that are to be found in the Atlantic Ocean, since in their passage westward, if this took place in geologically recent times, they must have been able to survive transfer across the region of admixture of warm and cold water off South Africa, where the Benguela current has its origin. It is thus possible that these species have not originated in the south-east Pacific area, but have been swept eastward from the south-west region or even from further west from the Indian Ocean, and have managed to survive in the cold water of the West Wind Drift and the Humbolt Current. Such a transfer would be in keeping with the suggestion put forward by Cleve (1904) that the explanation of the presence of a number of species in both the Agulhas Current off the south-east corner of Cape Colony and off the west coast of South America is due to the steady flow of the mingled waters of the Agulhas Current and the West Wind Drift eastward across the southern part of the Pacific Ocean to the Humboldt Current. If this were so we should expect to find most, if not all, of these species present on the south coast of Australia ; from this region we have records (*vide* Brady, 1883, and Nicholls, 1944) of the following :

**Nannocalanus minor* (Claus) (as *Calanus valgus*).
**Undinula darwini* (Lubb.).
**U. vulgaris* (Dana).
**Acrocalanus gracilis* Giesbr.
**Clausocalanus furcatus* (Brady).

Euchæta marina (Prestand.) (as *E. prestandrea*).
**Centropages violaceus* (Claus).
**Gladioferens brevicornis* Henry.
G. inermis Nicholls.
**Temora stylifera* (Dana).
Pseudodiaptomus cornutus Nicholls.
**Pseudocyclops australis* Nicholls.
**Calanopia thompsoni* A. Scott.
**Candacia pectinata* Brady.
**Labidocera cervi* Krämer.
L. caudata Nicholls.
Acartia denticornis Brady.
**Tortanus barbatus* (Brady).
Oithona attenuata Farran.
**O. nana* Giesbr.
Oncæa obtusa Dana (? = *O. venusta* Philippi).
**Corycæus speciosus* Dana (as *C. varius*).
Sapphirina ovalis Dana.
**Copilia mirabilis* Dana.
**Macrosetella gracilis* (Dana).

A comparison of the above list with that of the species that have been recorded from the southern region of the east Pacific Ocean, but have not as yet been taken in the northern area, shows that only three are common to both lists, namely *Temora stylifera* (Dana), *Oithona attenuata* Farran and the doubtful species *Acartia denticornis* Brady, and possibly a fourth, *Undinula darwini* (Lubb.), if I am right in thinking that *U. caroli* Giesbr. is a synonym. Six of the South Australian species are peculiar to this region or the Tasman Sea, namely :

Gladioferens brevicornis Henry,
G. inermis Nicholls,
Pseudodiaptomus cornutus Nicholls,
Pseudocyclops australis Nicholls,
Labidocera cervi Krämer,
L. caudata Nicholls,

and these are probably endemic. Seven species have been recorded from the West Wind Drift, namely *Nannocalanus minor* (Claus), *Undinula darwini* (Lubb.), *Clausocalanus furcatus* (Brady), *Euchæta marina* (Prestand.), *Centropages violaceus* (Claus), *Corycæus speciosus* Dana and *Macrosetella gracilis* (Dana), and to these may be added the doubtful species *Acartia denticornis* Brady; these species may perhaps have reached the south coast of Australia from the west, during that part of the year in which the main trend of the current in the coastal region is from west to east, namely August and September (*vide* Schott, 1935, pl. xxx), but as many as 18, marked with an asterisk, have been recorded by Dakin and Colefax (1933) and Henry (1919) from New South Wales and, with the exception of *Gladioferens brevicornis*, that is a fresh- or brackish-water form, all of them are known to be inhabitants of the south-west Pacific area, and in addition *Oithona attenuata* Farran is known from the same region, and there can be little doubt that they

have reached their habitat on the South Australian coast in the branch of the East Australian Current that turns westward along the south coast of Australia during the months February–March and later (*vide* Schott, 1935, pl. xxix).

I think therefore that it is much more probable that the transfer of most of the 24 species that are known from the south area of the east Pacific region, but not from the north area, has been brought about from east to west in the South Equatorial Current, though the following species may possibly be exceptions to this, namely :

Drepanopus forcipatus Giesbr.
Scolecithricella minor (Brady).
Centropages brachiatus (Dana).
Acartia Lilljeborgi Giesbr.
Oncæa curvata Giesbr.
O. notopus Giesbr.
Corycæus (*Corycella*) *gracilis* Dana.
Euterpina actifrons (Dana).

All of these are known to be inhabitants of the West Wind Drift (*vide infra*, p. 453). *Drepanopus forcipatus* Giesbr. and *Acartia lilljeborgi* Giesbr. have been recorded from both west and east coasts of South America, and Steuer (1933) has attempted to explain the distribution of the latter species by assuming that it was in existence in the Tertiary epoch, when there was a direct communication between the Atlantic and Pacific Oceans across Central America, and that the species migrated southwards from the tropics along both coasts ; this explanation, however, assumes that the migration was carried out against the trend of the currents, as they flow to-day, on both, but especially on the west side of South America. In the genus *Drepanopus* the only other known species, *D. pectinatus* Brady, is a denizen of the Sub-polar Antarctic region and the West Wind Drift, and has been recorded as present in large numbers round the Falkland Islands, South Georgia and Kerguelen, and it seems probable that *D. forcipatus* has a similar habitat, and that both it and *Acartia lilljeborgi* have been swept northwards up the west coast of South America by the branch of the West Wind Drift that forms the Humboldt Current and up the east coast in the Falkland Island Current, though this does not at the present time run as far to the north as the position in which *Acartia lilljeborgi* has been taken.

As regards *Oncæa notopus* Giesbr., it is much more likely that it is a tropical form that has managed to penetrate into the West Wind Drift, since it has been recorded from the warm water of the Japanese coast in the Pacific Ocean and from the tropical region of the Indian Ocean, and even as far north as the Gulf of Suez. That it is an extremely hardy species is shown by the fact that it has been recorded by Sars from the New Siberian Islands in the Arctic Ocean, and is stated by Hardy and Günther (1935, p. 192) to be widespread in the Antarctic, extending across the Antarctic convergence towards the Falkland Islands. On the other hand *Oncæa curvata* Giesbr. may be an Antarctic species that has spread northwards across the Antartic convergence into the West Wind Drift and so has reached the south-east Pacific area.

Between the north and south Pacific regions lies the region of the Counter-equatorial Current that flows from west to east. From this belt, thanks to the work of Giesbrecht (1892) and Wilson (1942), as many as 137 species have been recorded ; of these 102 are known from the west Pacific region, and their presence can thus be accounted for by trans-

ference eastward from the Asiatic to the American side of the ocean. Along both margins of the current lie the tropical convergence zones, in which there is some, and possibly a considerable, mixing of the water with the north and south Equatorial currents, and this may account for the presence in the Contra-Equatorial Current of the species *Scolecithricella minor* (Brady), *Temora stylifera* (Dana) and *Oncœa curta* Sars, which have been recorded from the southern area of the Pacific but are as yet unknown from either the northern or western areas, and *Corycœus clausi* F. Dahl and *C. anglicus* Lubb., which have been recorded by Wilson (1942) from the northern and central areas of the east Pacific Ocean but are unknown from the southern or western regions. A few of Wilson's records, however, appear to be open to doubt; he has recorded from the Pacific Ocean the following species:

Calanus propinquus Brady.
Oncœa anglica Brady.
O. similis Sars.
O. tenella Sars.
Corycœus anglicus Lubb.
Ægisthus spinulosus Farran.

Calanus propinquus is an Antarctic species and the other five have previously only been recorded from the North Atlantic Ocean or its offshoots; if their presence in the Pacific Ocean be confirmed, the explanation may be found in the existence of the open connection between the Atlantic and Pacific Oceans in Tertiary times, or else in their transference through the Arctic region.

Four species, namely,

Euchœta flava Giesbr.,
E. grandiremis Giesbr.,
Labidocera lubbocki Giesbr.,
Pontella agassizi Giesbr.,

have up to the present time only been recorded from the tropical region of the east Pacific and may be regarded as endemic; this is especially true of *Labidocera lubbocki*, which was originally recorded from the estuary of the Guayaquil River and is thus an inhabitant of brackish water. A fifth species that appears to be endemic in this region is *Pseudodiaptomus culebrensis* Marsh but this is a fresh-water form. A single species, *Vettoria granulosa* (Giesbr.) (= *Corina granulosa*) is at present known only from the tropical eastern Pacific region, the Mediterranean Sea and the coast of Ireland, and a possible explanation of this discontinuous distribution may lie in the connection that existed in Tertiary times between the Pacific and Atlantic Oceans through the Tethys Sea.

I have already pointed out that the North and South Equatorial Currents provide a highway along which planktonic organisms can be swept westwards from the East Pacific region; we should therefore expect to find that many of the warm-water species from the coast of North America and the neighbouring area of the North Pacific Ocean have been carried westward to the west Pacific area in the region of the Philippine Islands, and from thence they can be swept northwards by the Kuro-Siwo Current and its branches and so reach the region round Japan. Our knowledge of the Japanese fauna was still very incomplete until Wilson (1942) published his report on the results of the "Carnegie"

investigations. I have been able to collate references to 118 species from this area (*vide* Brady (1883), Marukawa (1908), Sato (1913), Mori (1929, 1932 and 1935), Kurasige (1931), Tanaka (1936, 1937) and Wilson (1942)).

The species present are as follows :

**Calanus cristatus* Kröyer.
**C. finmarchicus* Gunn.
C. ramosus Mori.†
C. syumpuensis Kurasige.
C. tenuicornis Dana.
Nannocalanus minor (Claus).
Canthocalanus pauper (Giesbr.).
Undinula caroli (Giesbr.).
U. darwini (Lubb.).
U. vulgaris (Dana).
U. vulgaris var. *plumulosus* (as *Calanus orientalis* Marukawa).
Eucalanus mucronatus Giesbr.
E. oculanus Marukawa (? = *E. crassus* Giesbr.).
E. setiger Brady.
E. subtenuis Giesbr.
Rhincalanus cornutus f. *typica* Dana.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
? *P. pygmæus* (Claus).
Acrocalanus gibber Giesbr.
A. gracilis Giesbr.
A. longicornis Giesbr.
A. monachus Giesbr.
Calocalanus pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
**Pseudocalanus minutus* Kröyer (= *elongatus* (Boeck)).
**Microcalanus pusillus* Sars.
**M. pygmæus* Sars.
**Ctenocalanus vanus* Giesbr.
Euchæta acuta Giesbr.
E. japonica Marukawa.
E. marina (Prestand.).
E. marina var. *longispinosa*.
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).

† This "species" appears to be based on an abnormal and, possibly, immature individual. The rounded posterior thoracic margin resembles that of *Undinula darwini* var. *symmetrica* Sewell, and the branched character of the furcal setæ is an abnormality that has been noticed in several species. It seems probable that this species is a synonym of *Undinula darwini*, just as *Calanus orientalis* Marukawa is a synonym of *Undinula vulgaris* (Dana) var. *plumulosus* Wolfend. (*vide* Früchtl, 1924, p. 15).

S. ovata (Farran).
Centropages abdominalis.
C. calaninus (Dana).
C. elongatus Giesbr.
C. furcatus (Dana).
**C. hamatus* (Lillj.).
C. longicornis Mori.
C. orsinii Giesbr.
C. violaceus Brady.
Temora discaudata Giesbr.
**T. longicornis* (Müll.).
T. turbinata (Dana).
**Eurytemora pacifica* Sars. (? = *E. johanseni* Willey).
Pseudodiaptomus marinus.
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bicornuta Mori.
C. bispinosa Claus.
C. bipinnata Giesbr.
C. catula Giesbr.
C. curta Dana.
C. curva Mori.
C. longimana Claus.
**C. norvegica* Boeck.
C. pachydactyla Dana.
C. pectinata Brady (= *armata* Boeck).
C. simplex Giesbr.
C. tenuimana Giesbr.
C. truncata Dana.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. bipinnata Tanaka (? = *L. pectinata* Thomp. and A. Scott).
L. detruncata (Dana).
L. japonica Mori.
L. rotunda Mori (? = *L. pectinata* Thomp. and A. Scott, ♂).
L. pavo Giesbr.
L. wollastoni (Lubb.).
Pontella atlantica (M. E.).
P. barbata Tanaka.
P. bifurvata Tanaka.
P. forcipata Tanaka.
P. longipedata Sato.
P. securifer Brady.
P. whiteleggei Krämer.
**Anomalocera patersoni* Templ.
Pontellopsis æqualis Mori.

**Acartia bifilosa* Giesbr. (probably *A. clausi* Giesbr.).
A. danæ Giesbr.
**A. longiremis* (Lillj.).
A. negligens Dana.
A. steueri Smirnov.
Oithona attenuata Farran.
O. nana Giesbr.
O. plumifera Baird.
O. setigera (Dana).
O. spinirostris Claus (= *O. atlantica* Farran).
Oncæa conifera Giesbr.
O. curvata Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
**O. notopus* Giesbr.
O. obtusa Brady.
O. similis Sars.
O. tenella Sars.
O. venusta Philippi.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*C.*) *crassiusculus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *typicus* Kröyer.
C. (*Urocorycæus*) *lautus* Dana.
C. (*U.*) *longistylis* Dana.
C. (*Ditrichocorycæus*) *dubius* Farran.
C. (*D.*) *lubbocki* Giesbr.
C. (*Onychocorycæus*) *obtusus* Giesbr.
C. (*O.*) *ovalis* Claus.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *curtus* Farran.
C. (*C.*) *gibbulus* Giesbr.
C. (*C.*) *rostratus* Claus.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. metallina Dana.
S. ovatolanceolata Dana—*gemma* Dana.
S. stellata Giesbr.
Copilia longistylis Mori.
C. mediterranea (Claus).
C. mirabilis Dana.
C. recta Giesbr.
Pachysoma dentatum Mori.

P. tuberosum Giesbr.
Microsetella norvegica (Boeck).
M. rosea Dana.
Macrosetella gracilis (Dana).
M. oculata Sars.
Euterpina acutifrons (Dana).
Miracia efferata Dana.
Clytemnestra scutellata Dana.

Several of the above species are known to be inhabitants of the Arctic Ocean and can have been drifted southwards, probably in the Oya-Shio Current; these I have indicated by an asterisk.

Twelve species appear up to the present time to be confined to the Japanese region and are possibly endemic; these are as follows:

? Calanus ramosus Mori.
C. syumpuensis Kurasige.
Pseudodiaptomus marinus.
Centropages longicornis Mori.
Labidocera japonica Mori.
Pontella barbata Tanaka.
Pontellopsis æqualis Mori.
Acartia steueri Smirnov.
Candacia bicornuta Mori.
Pontellopsis æqualis Mori.
Copilia longistylis Mori.
Pachysoma dentatum Mori.

The western tropical region of the Pacific Ocean is directly connected with the Indian Ocean by numerous channels that pass between the islands of the Malay Archipelago and between New Guinea and Australia. The direction in which the surface water flows through these channels depends in the main on the direction of the prevailing wind, and, in consequence of the alternation of the north-east and south-west monsoons, the current is reversed approximately every six months. One such channel connects the China Sea through the Strait of Malacca with the Andaman Sea and on through Preparis Channel, Ten Degree Channel and Great Channel with the Bay of Bengal and the Indian Ocean. In a previous paper (Sewell, 1929) I have pointed out that during the north-east monsoon in December–February the current flows in a westerly direction from the Pacific to the Indian Ocean. Michaelis (1923, chart 1) for the month of January and Schott (1936, pl. xxix) for the months February–March show a current of water flowing from the South China Sea through the Strait of Malacca into the Andaman Sea, while another stream of water passes through the Sunda Strait between Sumatra and Java into the Indian Ocean direct; at the same time a current sets eastward from the Timor Sea and the region off the north-west part of Australia through the Torres Strait into the Coral Sea and the Pacific Ocean. During the south-west monsoon, from June to September, the direction of flow is reversed and we get a flow of water eastward across the Indian Ocean between lats. 0°–10° N., and from this an offshoot passes into the Andaman Sea and then through the Strait of Malacca to the western Pacific Ocean. Michaelis (1923, chart 2) and Schott

(1936, pl. xxx), however, show that during the months of July–September a current runs westward from the Java Sea through the Sunda Strait, and from the Coral Sea through the Torres Strait into the Indian Ocean and on to the African coast, where in part it joins the Agulhas Current. More recently Myers (1943), summarizing our knowledge of the movement of the water in these regions, states that the season of the west monsoon extends from December to April, and that this wind induces currents that pass through the narrow channels between the Thousand Islands, and that in at least occasional years a deep stream of water passes from the Indian Ocean through the Sunda Strait and continues along the north coast of Java as far as the Bay of Batavia. During the east monsoon season, extending from April to December, typically oceanic water enters the Java Sea from the Flores Sea and the Indian Ocean. Such an interchange of surface water not only permits but must actually bring about a corresponding interchange of planktonic organisms. Another route by which surface-living organisms may be carried from the south-west Pacific region into the Indian Ocean is by the East Australian Current that sets southwards down the east coast of Australia, and during the months of February–March (*vide* Schott, 1936, pl. xxix) sends a branch westward through the Bass Strait between Australia and Tasmania and another to the south of Tasmania ; this current flows westward along the south coast of Australia, and then turns northwards along the west coast to join the South Equatorial Current in the Indian Ocean. It seems probable, however, that only the more hardy species could survive along this southerly route for, as we trace the planktonic surface-living species from the tropical and sub-tropical regions of the West Pacific Ocean past the Great Barrier Reef to the south coast of Australia, there is a marked decrease in the number of recorded species ; out of a total of some 147 species recorded from the Malay Archipelago, 87 have been taken on the Great Barrier Reef, 78 have been recorded by Dakin and Colefax (1933) in the coastal waters of New South Wales, but so far only some 18 or 19 have been recorded from South Australia (*vide supra*, p. 403).

Taking the eastern Pacific fauna as a whole, out of a total of 188 species 11 have a range that extends westward across the Pacific and on into the Indian Ocean but have not as yet been recorded from beyond this latter region, namely,

Undinula caroli (Giesbr.) (? = *U. darwini* Lubb. var.),
Euchæta longicornis Giesbr.,
Pontella danæ Giesbr.,
Tortanus forcipatus (Giesbr.).,
Pontella princeps Dana,
Pachysoma tuberosum Giesbr.,
Corycæus (*Corycæus*) *vitreus* Dana,
C. (*Ditrichocorycæus*) *africanus* F. Dahl,
C. (*Onychocorycæus*) *pumilus* M. Dahl,
C. (*O.*) *pacificus* F. Dahl,
C. (*Corycella*) *concinnus* Dana,

and to these may be added *Labidocera trispinosa* Esterly, that has so far only been recorded from the eastern Pacific area and the Indian Ocean, though probably further investigations will reveal its presence in the western Pacific region also.

Fifty-one species have been able to extend their habitat into the Indian Ocean and on into the Red Sea, but have not been able to get as far north as the Gulf of Suez and the Suez Canal. These species are as follows :

Nannocalanus minor (Claus).
Undinula vulgaris (Dana).
Eucalanus crassus Giesbr.
E. pileatus Giesbr.
E. subcrassus Giesbr.
E. subtenuis Giesbr.
Rhincalanus cornutus f. *typica* Dana.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
Acrocalanus gracilis Giesbr.
A. longicornis Giesbr.
A. monachus Giesbr.
Calocalanus plumulosus (Claus).
Euchæta marina (Prestandr.).
Centropages gracilis (Dana).
Candacia æthiopica Dana.
C. bispinosa Claus.
C. catula Giesbr.
C. curta Dana.
C. simplex Giesbr.
C. truncata Dana.
Labidocera acutifrons (Dana).
Pontella fera Dana.
Pontellina plumata Dana.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Planktacartia*) *negligens* Dana.
Tortanus forcipatus (Giesbr.).
Oithona linearis Giesbr.
O. setigera (Dana).
Oncæa conifera Giesbr.
O. mediterranea Claus.
Lubbocki aculeata Giesbr.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C.(*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *longistylis* Dana.
C. (*Onychocorycæus*) *agilis* Dana.
C. (*O.*) *catus* F. Dahl.
C. (*O.*) *obtusus* Dana (? = *catus* F. Dahl).
C. (*Corycella*) *carinatus* Giesbr.
Sapphirina auronitens Claus—*sinuicauda* Brady.

S. bicuspidata Giesbr.
S. metallina Dana.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. scarlata Giesbr.
Copilia mirabilis Dana.
Microsetalla rosea Dana.
Macrosetella gracilis (Dana).
Ægisthus aculeatus Giesbr.

Twenty-five other species from the East Pacific area have, so far as our present records go, reached the Red Sea and have been carried as far north as the Gulf of Suez, namely :

Canthocalanus pauper (Giesbr.).
Undinula darwini (Lubb.).
Paracalanus parvus (Claus).
Acrocalanus gibber Giesbr.
Clausocalanus arcuicornis (Dana).
Centropages calaninus (Dana).
C. furcatus (Dana).
Temora discaudata Giesbr.
Lucicutia flavicornis (Claus).
L. stylifera (Dana).
Labidocera acuta (Dana).
Acartia clausi Giesbr.
A. negligens Dana.
Oithona nana Giesbr.
O. plumifera Baird.
O. similis Claus.
Oncœa media Giesbr.
O. minuta Giesbr.
O. venusta Philippi.
Corycæus (*Corycæus*) *crassiusculus* Dana.
Lubbockia squillimana Claus.
Microsetalla norvegica (Boeck).
Euterpina acutifrons (Dana).
Clytemnestra rostrata (Brady).
C. scutellata Dana.

Munro Fox (*vide* Gurney, 1927, p. 171) is of the opinion that *Acartia clausi* Giesbr. has reached the Suez Canal from the Mediterranean Sea ; it has, however, been recorded by Thompson (1900) from several stations in the Indian Ocean, the Bay of Bengal and the Red Sea.

In view of the fact that for about half the year there is a strong surface current setting through the Gulf of Aden and the Strait of Bab-el-Mandeb from the Arabian Sea to the Red Sea, it is at first sight somewhat surprising that, comparatively, so few of the surface-living Copepoda that are known to be present in the Arabian Sea have succeeded in getting

into the Red Sea and reaching the Gulf of Suez and the Suez Canal. This subject will be dealt with later, when considering the distribution of the planktonic Copepoda of the Indian Ocean (*vide infra*, p. 432).

A very large number of the eastern Pacific species appears to have succeeded in reaching the tropical and south temperate regions of the Atlantic Ocean, in which the following have been recorded :

Nannocalanus minor (Claus).
Canthocalanus pauper (Giesbr.).
Undinula darwini (Lubb.).
U. vulgaris (Dana).
Eucalanus crassus Giesbr.
E. monachus Giesbr.
E. mucronatus Giesbr.
E. pileatus Giesbr.
E. subcrassus Giesbr.
E. subtenuis Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. parvus (Claus).
Acrocalanus longicornis Giesbr.
Calocalanus pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Euchæta acuta Giesbr.
E. marina (Prestandr.).
E. media Giesbr.
E. philippi Brady.
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).
S. minor (Brady).
Centropages brachiatus (Dana).
C. bradyi Wheeler.
C. calaninus (Dana).
C. furcatus (Dana).
C. gracilis (Dana).
Temora stylifera (Dana).
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bipinnata Giesbr.
C. bispinosa Claus.
C. curta Dana.
C. pachydactyla Dana.

C. pectinata Brady.
C. simplex Giesbr.
C. truncata Dana.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
Pontella atlantica (M. E.).
P. fera Dana.
P. securifer Brady.
Pontellopsis regalis (Dana).
Pontellina plumata Dana.
Acartia clausi Giesbr.
A. danæ Giesbr.
A. negligens Dana.
A. tonsa Dana.
Oithona atlantica Farran.
O. attenuata Farran.
O. brevicornis Giesbr.
O. nana Giesbr.
O. plumifera Baird.
O. setigera (Dana).
O. similis Claus.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
O. notopus Giesbr.
O. subtilis Giesbr.
O. venusta Philippi.
Conæa rapax Giesbr.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *furcifer* Claus.
C. (*U.*) *lautus* Dana.
C. (*Onychocorycæus*) *agilis* Dana.
C. (*O.*) *catus* F. Dahl.
C. (*O.*) *giesbrechti* F. Dahl.
C. (*O.*) *ovalis* Claus.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gibbulus* Giesbr.

C. (*C.*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. bicuspidata Giesbr.
S. iris Dana.
S. metallina Dana.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. stellata Giesbr.
S. scarlata Giesbr.
Copilia lata Giesbr.
C. mediterranea (Claus).
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea (Haeckel).
Pontœciella abyssicola (T. Scott).
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Miracia efferata Dana.
Macrosetella gracilis (Dana).
M. oculata Sars.
Clytemnestra rostrata (Brady).
C. scutellata (Dana).
Ægisthus mucronatus Giesbr.
A. aculeatus Giesbr.

In the above list I have included *Candacia pectinata* Brady, which has not as yet been recorded from the south-west Pacific area though it has been taken in the region of Japan, and *Euchæta philippi* Brady and *Centropages bradyi* Wheeler, which are not known from the Indian Ocean ; indeed the former species is of doubtful validity but I have included it here for the sake of completeness, and we may also add those other doubtful species, *Acartia laxa* Dana and *A. denticornis* Brady. If we include these additional species in the list of those that appear to have been carried westward at some time in the past into the Atlantic Ocean we have no less than 112 species that have undergone this transfer. We have already seen that 188 species have been recorded from the east Pacific region, but of these 19 may have been carried southwards into this area from the Arctic Ocean and 2 others have been swept northwards from the West Wind Drift ; these 21 species therefore should not be regarded as true east Pacific species ; this leaves us with 167 East Pacific species, and of these 112, or 67 per cent., have reached the Atlantic Ocean. So far as the available evidence goes, four of these species, namely,

Canthocalanus pauper (Giesbr.),
Centropages calaninus (Dana),
Pontella fera Dana,
Oithona attenuata Farran,

have only succeeded in getting into the south temperate region, and in this area *Corycella rostrata* Claus has given rise to a variety, var. *longa* Kleverhusen. Eight others, namely,

Undinula darwini (Lubb.),
Eucalanus pileatus Giesbr.,
E. subcrassus Giesbr.,
Candacia truncata Dana,
Corycæus (*Onychocorycæus*) *agilis* Dana,
C. (*Monocorycæus*) *robustus* Giesbr.,
C. (*Corycella*) *gibbulus* Giesbr.,
Clytemnestra rostrata (Brady),

have got as far as the tropical region. All the others have been recorded from the North Temperate region of the Atlantic.

As we pass westwards from the American coast across the Pacific we meet with numerous groups of islands, but our knowledge of the fauna of these regions is far from complete : several species of Copepod have, however, been recorded by Dana (1847–49), Streets (1877) and Giesbrecht (1892), and I give the position from which they have been recorded :

		Lat.	Long.
Candacia longimana Claus	from	16° N.	165° E.
C. tenuimana Giesbr.	,,	16° N.	166° E.
Pontellopsis armata (Giesbr.)	,,	10° N.	137° E.
P. villosa Brady	,,	30° N.	155° W.
Sapphirina gastrica Giesbr.	,,	19° N.	175° W.
S. intestinata Giesbr.	,,	11°–15° N.	143° E.

None of these species has, so far, been recorded from the East Pacific region, and it is possible that they have actually originated around these islands between lats. 10°–30° N. If this be so, they have, as a study of the surface currents indicates, been swept westward in the North Pacific Equatorial Current and so have reached the west Pacific region. From this region they have all been carried still further westward into the Indian Ocean, and *Candacia longimana* Claus has reached the Red Sea but has not got as far north as the Gulf of Suez. Both species of *Candacia*, *longimana* Claus and *tenuimana* Giesbr., *Pontellopsis villosa* Brady and *Sapphirina gastrica* Giesbr. have been carried as far westward as the Atlantic Ocean ; the last two species have been taken in the Woods Hole region of the east coast of North America, and *Sapphirina gastrica* Giesbr. has got into the Mediterranean Sea. Similarly, in the region south of the Equator, Dana (1847–49) has recorded a number of species from the Polynesian and Micronesian regions : most of these are known from further east but two, namely *Pontellopsis strenua* Dana, recorded from lat. 3° S., long. 173° E., and *Oithona oculata* Farran, recorded by Rosendorn from Samoa, may have originated in this region and, if so, have probably been carried westward in the South Equatorial Current, and this would account for their presence in the west Pacific and Indian regions respectively.

Turning now to the tropical and temperate regions of the western part of the Pacific Ocean, thanks to the work of Brady (1883, 1899), Giesbrecht (1892), Krämer (1894), Cleve (1901), Sars (1905), Carl (1907), A. Scott (1909), Rosendorn (1912), Früchtl (1924),

Farran (1929, 1936), Smith (1941), Wilson (1942), and Vervoort (1946), I have been able to collect references to 110 species that have so far not been recorded from further east, namely:

**Eucalanus dentatus* A. Scott.
Paracalanus crassirostris F. Dahl, var. *typicus* Früchtl.
P. denudatus Sewell.
Acrocalanus gardineri Wolfenden.
A. inermis Sewell.
Calocalanus contractus Farran.
**C. pavoninus* Farran.
Clausocalanus farrani Sewell.
C. paululus Farran.
C. pergens Farran.
Euchæta concinna Dana.
E. consimilis Farran.
E. pubera Sars.†
**E. russelli* Farran.
E. wolfendeni A. Scott.
**Xanthocalanus squamatus* Farran.
**Macandrewella asymmetrica* Farran.
**M. joanæ* A. Scott.
**M. mera* Farran.
**M. sewelli* Farran.
Scolecithricella dentata (Giesbr.).
S. nicobarica Sewell.
S. tenuiserrata (Giesbr.).
**Scolecocalanus galeatus* Farran.
Centropages auklandicus Krämer (= *C. discaudatus* Brady).
C. elongatus Giesbr.
C. kröyeri Giesbr.
C. orsinii Giesbr.
**Gladioferens pectinatus* (Brady) (= *Centropages pectinatus* Brady).
Temora longicornis (O. F. Müller).
T. turbinata (Dana) (? = *T. tenuicauda* Brady).
Temoropia mayumbæensis (T. Scott).
Pseudodiaptomus aurivillii Cleve.
P. clevei A. Scott.
**P. dauglishi* Sewell.
P. mertoni Früchtl.
Metacalanus aurivillii Cleve.
Candacia bradyi A. Scott.
C. discaudata A. Scott.
C. longimana Dana.
C. tenuimana Giesbr.

† Sars (1925) and Rose (1933) regard *E. wolfendeni* A. Scott as a synonym of this species, but Farran (1929) dissents from this view.

C. varicans Giesbr.
Labidocera bataviæ A. Scott.
**L. bipinnata* Tanaka (? = *pectinata* Thomp. and A. Scott).
**L. cervi* Krämer.
**L. glauca* Smith.
·*L. kröyri* (Brady).
L. euchæta Giesbr.
L. lævidentata (Brady).
L. maduræ A. Scott.
L. minuta Giesbr.
L. pavo Giesbr.
L. pectinata Thompson and A. Scott (? = *L. bipinnata* Tanaka).
**Ivellopsis elephas* Brady.
**Pontella alata* A. Scott.
**P. cerami* A. Scott.
**P. chierchiæ* Giesbr.
**P. cristata* Krämer.
P. denticauda A. Scott.
**P. forficula* A. Scott.
**P. kieferi* Pesta.
**P. longipedata* Sato.
**P. novæ-zelandiæ* Farran.
P. whiteleggei Krämer.
Pontellopsis armata (Giesbr.).
P. macronyx A. Scott.
P. perspicax (Dana).
**P. pexa* A. Scott.
P. strenua (Dana).
P. tenuicauda (Giesbr.).
P. villosa Brady.
Calanopia aurivillii Cleve.
C. elliptica (Dana).
C. herdmani A. Scott.
C. minor A. Scott.
C. thompsoni A. Scott.
**Acartia* (*Odontacartia*) *australis* Farran.
A. (*O.*) *amboinensis* Carl.
A. (*O.*) *bispinosa* Carl.
A. (*O.*) *erythræa* Giesbr.
A. (*O.*) *pacifica* Steuer.
A. (*O.*) *spinicauda* Giesbr.
A. (*Acanthacartia*) *bifilosa* Giesbr.
A. (*Acartiura*) *ensifera* Brady (= *A. clausi* Giesbr.).
(*)*A.* (*A.*) *simplex* Sars (? = *A. clausi* Giesbr.).
Tortanus barbatus (Brady).
T. gracilis (Brady).

T. (*Atortus*) *brevipes* A. Scott.
**T.* (*A.*) *murrayi* A. Scott.
Oithona fallax Farran.
O. minuta T. Scott.
O. rigida Giesbr.
O. robusta Giesbr.
O. simplex Farran.
O. tenuis Rosendorn.
Oncœa clevei Früchtl.
Corycœus (*Ditrichocorycœus*) *asiaticus* F. Dahl.†
C. (*D.*) *dubius* Farran.
C. (*D.*) *erythrœus* Cleve.
**C.* (*D.*) *farrani* Früchtl.
C. (*D.*) *inuncus* Farran.
C. (*D.*) *lubbocki* Giesbr.
C. (*D.*) *minimus* F. Dahl.
C. (*D.*) *subtilis* M. Dahl.
Sapphirina intestinata Giesbr.
S. gastrica Giesbrecht.
S. lactens Giesbrecht.
S. sali Farran, (= *pseudolactens* Rosendorn).
Ectinosoma australe Sars (= *E. melaniceps* Boeck).
**Corissa parva* Farran.

Further investigations may reveal the presence of certain of these species in the eastern part of the Pacific Ocean, but it is equally possible that at least the majority of these forms have actually originated in the tropical and sub-tropical western and south-western region, and have not as yet been carried eastward and been able to survive in the south-eastern region of the Pacific Ocean. Of the species contained in the above list those that are marked with an asterisk have not, up to the present time, been recorded from any other region; one of these species may be a synonym and this I have indicated by putting the asterisk in brackets. Excluding this, we have 28 species that appear to be entirely local in their distribution and so may be regarded as endemic. In addition to these marine species certain others, belonging to marine genera, appear to have evolved in this western Pacific region and have invaded brackish- or even fresh-water; in all probability it is this invasion of brackish-water areas that has been responsible for the evolution of the new species. Such species are:

Pseudodiaptomus dauglishi Sewell,
Cyclopinodes pusilla (Sars),

which are brackish-water species, and

Sinocalanus mystrophorus Burckhardt,
S. solstitialis Brehm,
S. tenellus (Kikuchi),
Limnocalanus sinensis Poppe,

† M. Dahl (1912, p. 77) has suggested that *Corycœus asiaticus* F. Dahl may be a synonym of *Corycœus auklandicus* Krämer, described from New Zealand.

Pseudodiaptomus forbesi Poppe and Mrazek,
P. inopinus Burckhardt,
P. japonicus Kikuchi, (? = *P. inopinus*),
P. nostradamus Brehm,
P. poppei Stingelin,
P. smithi Wright,
P. trihamatus Wright,
Limnoithona sinensis Burckhardt,

all of which are inhabitants of fresh-water and have not up to the present time been recorded from any other region.

In past geological ages there have been very considerable changes in the character of the East Indies and the Malayan region. In late Cretaceous and early Tertiary times the connection between the Pacific and Indian Oceans appears to have been considerably more extensive than it is at the present day. With the upheaval of the Himalayan mountain system in Tertiary times a series of ridges arose forming the Malayan and the Andaman-Sumatra-Timor arcs. This process continued throughout Eocene and Miocene times, and Kuenen (1935, p. 106) remarks, " Nearly all the islands in the eastern part of the Indies show signs of recent elevation, so that we can hardly be wrong in supposing that in a comparatively recent period the island arcs were hardly anywhere above sea-level. . . . This means that taken as a whole the amount of relief is increasing, and that therefore the Archipelago consisted of smaller and fewer islands or was even almost entirely submarine at the close of the Tertiary period." During the Pleistocene Glacial epoch there occurred a general lowering of the sea-level in the tropical belt that brought about the appearance of two great land masses, the Sunda and Sahul shelves, between which the only connection between the Pacific and Indian Oceans ran in a north-east to south-west direction past the island of Celebes. Still later with the rise of sea-level, consequent on the melting of the ice and continued orogenetic movement the present conditions arose and numerous connections were formed between the two regions. Throughout the whole period it seems probable that the surface interchange between the two oceans was reversed twice each year with the alternating north-east and south-west monsoons. Such an interchange must have brought about an admixture of Indian and Pacific plankton, and hence such species as are known to occur in both the south-west Pacific and the Indian regions may have originated in either area and have subsequently been swept in either direction ; thus the number of indigenous species from the south-west Pacific, as given above, may be too high, for some, and possibly all, those that are known from these two areas but have not been found further to the east may have originated in Indian waters and subsequently have been carried eastward to the Pacific area or, *vice versa*, they may have arisen in the Pacific and have been swept westward.

Another and less direct route by which species may have been swept from the south-west Pacific region into the Indian Ocean is by means of the east Australian current and its continuation along the south coast of Australia during the months of January to May each year. Schott (1935, pl. xxix) shows that in February and March a warm branch of the east Australian current sweeps westward either between Australia and Tasmania or to the south of this latter island, and then flows on along the whole of the south coast of Australia, finally turning northwards up the west coast to join the south Equatorial

current in the Indian Ocean. In the month of February, Schott (1935, pl. xx) indicates that the temperature of the water along the south side of Australia lies between 15° and 20° C. The work of Dakin and Colefax (1933 and 1940) and Nicholls (1944) has given us records of a number of species from the south-east and south coasts of Australia ; these are as follows :

Calanus finmarchicus (Gunn.).
C. tenuicornis Dana.
Calanoides brevicornis (Claus).
Nannocalanus minor (Claus).
Canthocalanus pauper (Giesbr.).
Undinula darwini (Lubb.).
U. vulgaris (Dana).
Eucalanus crassus Giesbr.
E. monachus Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. parvus (Claus).
Acrocalanus gibber Giesbr.
A. gracilis Giesbr.
Calocalanus plumulosus (Claus).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Ctenocalanus vanus Giesbr.
Euchæta concinna Dana.
E. marina (Prestand.).
Scolecithrix danæ (Lubb.).
Centropages bradyi Wheeler.
C. calaninus (Dana).
C. chierchiæ Giesbr.
C. furcatus (Dana).
C. gracilis (Dana).
C. kröyeri Giesbr.
C. orsinii Giesbr.
C. violaceus Brady.
Gladioferens brevicornis Henry.
Pseudodiaptomus hickmani Sewell, var.
Temora discaudata Giesbr.
T. stylifera (Dana).
T. turbinata (Dana).
Lucicutia flavicornis Claus.
Pseudocyclops australis Nicholls.
Candacia æthiopica Dana.
C. bipinnata Giesbr.
C. catula Giesbr.
C. pachydactyla Dana.

C. pectinata Brady.
C. truncata Dana.
Calanopia elliptica (Dana).
C. thompsoni A. Scott.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. brunescens (Czern.).*
L. caudata Nicholls.
L. cervi Krämer.
L. detruncata (Dana).
L. kröyeri Brady.
L. minuta Giesbr.
Pontella cristata Krämer.
P. novæ-zelandiæ Farran.
P. securifer Brady.
Pontellopsis regalis (Dana).
P. krämeri (Giesbr.).
Pontellina plumata Dana.
Acartia clausi Giesbr.
A. centrura Giesbr.
A. danæ Giesbr.
Tortanus barbatus Brady.
Oithona atlantica Farran.
O. brevicornis Giesbr.
O. nana Giesbr.
O. oculata Farran.
O. plumifera Baird.
O. setigera Dana.
O. similis Claus.
O. tenuis Rosendorn.
Oncæa conifer Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. venusta Philippi.
Corycæus africanus F. Dahl.
C. agilis Dana.
C. andrewesi Farran.
C. anglicus Lubb.†
C. catus F. Dahl.
C. clausi F. Dahl.
C. crassiusculus Dana.
C. furcifer Claus.

* I am inclined to doubt the correctness of this identification. *Labidocera brunescens* is a Mediterranean and Black Sea species, and though Dakin and Colefax state that it has been taken in the Indian Ocean, I have not been able to confirm this.

† I doubt the correctness of this identification.

C. giesbrechti F. Dahl.
C. latus Dana.
C. lautus Dana.
C. lubbocki Dana.
C. longistylis Dana.
C. pacificus F. Dahl.
C. speciosus Dana.
C. tenuis Giesbr.
C. vitreus Dana.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *concinnus* (Dana).
C. (*C.*) *gibbulus* Giesbr.
C. (*C.*) *rostratus* (Claus).
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. gastrica Giesbr.
S. intestinata Giesbr.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
S. stellata Giesbr.
Copilia mirabilis Claus.
C. quadrata (Dana).
C. vitrea (Haeckel).
Microsetella rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).

The great majority of these species were taken during the months January–May; during the succeeding months of July–September there is a marked decrease in the number of species recorded, but a few were taken that have not been recorded in the earlier months, namely:

Rhincalanus cornutus Dana.
Calanoides patagoniensis Brady.
Scolecithrix danæ (Lubb.).
Centropages violaceus (Claus).
Corycaeus (*Onychocorycæus*) *giesbrechti* F. Dahl.
Sapphirina opalina Dana.

During the months August–September the south Australian coast as far east as Tasmania is bathed by water that is coming out of the Indian Ocean and is flowing eastwards; and it is interesting to note that all these last species are known to be inhabitants of that Ocean. To the above list of species, that have in all probability been carried to the South Australian coast from the Indian Ocean, should be added *Corycæus* (*Ditrichocorycæus*) *africanus* F. Dahl, which occurs in this area from January to August, and *Pseudodiap-*

tomus hickmani Sewell var. taken in the spring. Later in the year, in October–December, the number of recorded species falls still lower to 15, and among these are—

> *Calanoides brevicornis* (Lubb.),
> *Centropages chierchiæ* Giesbr.,
> *Labidocera detruncata* (Dana),
> *Corycæus* (*Corycella*) *rostrata* (Claus),
> *Sapphirina angusta* Dana,

all of which have been recorded from the Indian Ocean, though *Centropages chierchiæ* Giesbr. is essentially an Atlantic species and has only been taken in the south-western area of the Indian Ocean, to which it may have been carried, as I have suggested later (*vide infra*, p. 432), by the deep current of Atlantic intermediate water that flows eastward past the Cape of Good Hope and on across the southern part of the Indian Ocean to the Pacific.

Around the coasts of the Tasman Sea and along the south coast of Australia there has been, in the past, a marked invasion of fresh-water. This has been the case particularly in the Centropagidæ, in which two genera, *Gladioferens* and *Brunella*, are represented by a number of species. In the genus *Gladioferens* Henry we have records of the following seven species :

> *G. inermis* Nicholls from salt- or brackish-water in South Australia.
> *G. pectinatus* (Brady) from salt- or brackish-water in New Zealand.
> *G. imparipes* Thomson from salt- or brackish-water in Western Australia.
> *G. brevicornis* Henry from salt- or fresh-water in New South Wales.
> *G. spinosus* Henry from fresh-water in New South Wales.
> *G. gracilis* Kiefer from fresh-water in New Zealand.
> *G. subsalaria* Percival from fresh-water in New Zealand.

The genus *Brunella* Smith appears, with a single exception, to be confined entirely to fresh-water, and the following species have been recorded :

> *B. steeli* Henry from fresh-water in New Zealand.
> *B. ampulla* Searle ,, ,, Victoria, Australia.
> *B. expansa* Sars ,, ,, ,, ,,
> *B. longicornis* Searle ,, ,, ,, ,,
> *B. australis* Searle ,, ,, ,, ,,
> *B. viridis* Searle ,, ,, ,, ,,
> *B. salina* Nicholls from a salt lake, South Australia.
> *B. tasmanica* Smith from fresh water in Tasmania.

Nicholls (1944, p. 5), in a footnote, states that two other species in this genus have been recorded from Western Australia ; I have been unable to see this paper.* The distribution of these species taken in conjunction with the distribution of such marine species as *Labidocera cervi* Krämer points to a transfer of species from the New Zealand region round the Tasman Sea and along the east coast of Australia, by the East Australian Current, and then westward along the south coast of Australia at some earlier period.

* Fairbridge, W. S., 1944, 'Journ. Roy. Soc. West. Aust., xxix.

A number of species that seem, so far as the present evidence goes, to have had their origin in the central and western Pacific region, have been recorded from regions lying to the west; up to the present time 31 of these species have been taken in the Indian Ocean, but have not, as yet, been recorded from either the Red Sea or the Atlantic Ocean, namely:

Paracalanus dubia Sewell (=*P. crassirostris* F. Dahl, var. *sewelli* Früchtl).
P. denudatus Sewell.
Acrocalanus gardineri Wolfenden.
A. inermis Sewell.
Clausocalanus farrani Sewell.
Euchæta consimilis Farran.
E. wolfendeni A. Scott.
Scolecithricella nicobarica Sewell.
Pseudodiaptomus aurivillii Cleve.
P. mertoni Früchtl.
Metacalanus aurivillii Cleve.
Candacia discaudata A. Scott.
Labidocera bataviæ A. Scott.
L. euchæta Giesbr.
L. lævidentata (Brady).
L. maduræ A. Scott.
Pontella denticauda A. Scott.
Pontellopsis armata (Giesbr.).
P. macronyx A. Scott.
Calanopia aurivillii Cleve.
C. herdmani A. Scott.
C. thompsoni A. Scott.
Acartia (*Odontacartia*) *amboinensis* Carl.
A. (*O.*) *bispinosa* Carl.
A. (*O.*) *pacifica* Steuer.
A. (*O.*) *spinicauda* Giesbr.
Oithona oculata Farran.
Oncæa clevei Früchtl.
? *Corycæus dubius* Farran (= *erythræus* Cleve).
Sapphirina intestinata Giesbr.
S. sali Farran (= *pseudolactens* Rosendorn).

Twelve species have been able to pass through the Indian Ocean and have been recorded from the Red Sea, but have not reached the Gulf of Suez, namely:

Euchæta concinna Dana.
Centropages elongatus Giesbr.
C. orsinii Giesbr.
C. violaceus (Claus).
Candacia bradyi Wheeler.
C. longimana Dana.
Pontellopsis krämeri Giesbr.

Calanopia minor A. Scott.
Tortanus barbatus (Brady).
Oithona minuta T. Scott.
O. rigida Giesbr.
Corycæus lubbocki Giesbr.

And finally 9 species have reached the Gulf of Suez and the Suez Canal, to wit:

Paracalanus crassirostris F. Dahl.
Labidocera minuta Giesbr.
L. pavo Giesbr.
Calanopia elliptica (Dana).
Acartia (Odontacartia) erythræa Giesbr.
Tortanus gracilis (Brady).
Oithona simplex Farran.
Corycæus (Ditrichocorycæus) asiaticus F. Dahl.
C. (D.) erythræus Cleve.

A number of species that appear to have had their origin in the west Pacific region inasmuch as they have never. up to the present time, been recorded from waters lying further to the east. have been taken in the Atlantic Ocean, and there seems little doubt that many, if not most, of these have been swept in a westerly direction past the Cape of Good Hope in a branch of the Agulhas Current. These species are as follows:

Paracalanus crassirostris F. Dahl.
Calocalanus contractus Farran.
Clausocalanus paululus Farran.
C. pergens Farran.
Euchæta concinna Dana.
E. pubera Sars.
Scolecithricella dentata (Giesbr.).
Centropages kröyeri Giesbr.
C. violaceus Brady.
Temora longicornis (O. F. M.).
T. turbinata (Dana).
Temoropia mayumbæensis (T. Scott).
Candacia longimana Dana.
C. tenuimana Giesbr.
C. varicans Giesbr.
Labidocera kröyeri (Brady).
L. nerii (Kröyer).
Pontellopsis perspicax (Dana).
P. villosa Brady.
Oithona minuta T. Scott.
O. robusta Giesbr.
O. simplex Farran.
O. tenuis Rosendorn.
Corycæus (Corycæus) clausi F. Dahl.
Ectinosoma melaniceps Boeck (= *E. australe* Sars).

Six of the above species, namely, *Clausocalanus paululus*, *C. pergens*, *Euchæta pubera*, *Temoropia mayumbæensis*, *Labidocera nerii* and *Corycæus* (*Corycæus*) *clausi* F. Dahl, have not as yet been recorded from the Indian Ocean, although they are known from both the west Pacific and the Atlantic ; it seems probable that further research will reveal their presence in the intermediate region. To these five species may be added *Corycaeus* (*Agetes*) *limbatus* Brady that is now known from the east and west Pacific regions and from the North Atlantic and Mediterranean regions, but is unknown from the Indian Ocean ; and the doubtful species *Eucalanus setiger* Brady, originally recorded from the west Pacific and later by T. Scott from the Gulf of Guinea, and by Thompson from the North Atlantic and the Mediterranean regions. Of the above species a few exhibit a very considerable range of tolerance to reduced salinity, and are frequently, if not invariably, taken in brackish water, such as *Paracalanus crassirostris* F. Dahl and *Oithona simplex* Farran, and the same may be said of the east Pacific species *Oithona brevicornis* Giesbr. ; such forms may have made their way westward along the inshore littoral margin by active migration, but they also appear to be capable of withstanding a wide range of salinity, and thus of surviving long passages across the open ocean ; on the other hand, if they were in existence in remote Tertiary times, it is possible that they reached their western habitat through the Tethys Sea, and this is most likely in the case of *Paracalanus crassirostris* F. Dahl, which has already developed local races in Indian waters and on both sides of the Atlantic Ocean (*vide* Früchtl, 1924, p. 36).

It is possible that the same explanation holds good in the case of *Temoropia mayumbæensis* (T. Scott) ; this species has been recorded from the south-west Pacific region, the Gulf of Suez, the Gulf of Guinea and the British Isles. The occurrence in the Gulf of Suez, however, appears open to doubt ; the record is by Thompson and A. Scott (1903), but the method of collecting was that previously adopted by Herdman of tying a muslin or silk bag to a bath-room tap and so filtering the water as it flowed out of the ship's tanks ; but this gives no indication as to the position of the ship when the water was pumped into the tanks from the sea. This must have been previous to the appearance of the organism in the tap-water, and may have been very considerably earlier. The only two occasions on which *Temoropia mayumbæensis* were taken were during the passage of the steamer outward bound through the Gulf of Suez, and it is possible that the water which contained the specimens was pumped in from the eastern part of the Mediterranean Sea. Assuming this to have been the case, the distribution of this species then becomes confined to the south-west Pacific, the Mediterranean Sea and the Gulf of Guinea, all three localities being either close to the entrance or exit or actually part of the ancient Tethys Sea. Two of the above species, namely, *Euchæta concinna* Dana and *Oithona tenuis* Rosendorn, have been unable to get any further than the tropical region of the Atlantic Ocean, but the great majority have been swept into the north temperate region, and their further distribution in that region will be dealt with later (*vide infra*, p. 459).

Turning now to the Indian Ocean, as many as 270 species have been recorded from this region or its offshoots the Persian Gulf and the Red Sea (*vide* Giesbrecht (1896), A. Scott (1902), Thompson (1900), Thompson and A. Scott (1903), Cleve (1901, 1903, 1904), Wolfenden (1906), Stebbing (1910), Pesta (1913), Farran (1911), Brady (1914, 1915), Sewell (1912, 1914, 1919, 1924, 1929, 1932), Gurney (1927) and Menon (1931)). A large number of species appear to have had their origin in this region, inasmuch as they have never, up to the present time, been recorded from further east. I have already pointed

out that there is a continuous connection through the Malay Archipelago and the Strait of Malacca between the Pacific and the Indian Oceans, and that it is thus difficult to draw a line between the two regions, but for convenience I have taken the eastern boundary of the Indian Ocean in the Strait of Malacca to be long. 100° E. Fifty-six species have so far not been recorded outside the Indian Ocean, namely :

Calanoides natalis Brady.†
Paracalanus nudus Sewell.
P. serratipes Sewell.
Euchæta affinis Cleve.
E. murrayi Sewell.
Macandrewella scotti Sewell.
Scolecithricella pearsoni Sewell.
Centropages alcocki Sewell.
C. dorsispinatus Thompson and A. Scott (= *notoceras* Cleve).
C. tenuiremis Thompson and A. Scott (= *arabicus* Cleve).
C. trispinosus Sewell.
C. tenuicornis Brady.
**Pseudodiaptomus annandalei* Sewell.
**P. binghami* Sewell.
P. burckhardti Sewell.
P. dubius Kiefer.
**P. lobipes* Gurney.
P. masoni Sewell.
**P. tollingeræ* Sewell.‡
**Isias tropica* Sewell.
Pseudocyclops simplex Sewell.
Labidocera chubbi Brady.
L. inermis Brady.
**L. gangetica* Sewell.
L. similis Cleve.
**Pontella andersoni* Sewell.
P. investigatoris Sewell.
P. natalis Brady.
P. spinipes Giesbr.
Pontellopsis herdmani Thompson and A. Scott.
P. scotti Sewell.
**Acartia* (*Acartiella*) *gravelyi* Sewell.
**A.* (*A.*) *kempi* Sewell.
**A.* (*A.*) *major* Sewell.
**A.* (*A.*) *minor* Sewell.
**A.* (*A.*) *sewelli* Steuer.
**A.* (*A.*) *tortaniformis* Sewell.
**A.* (*Euacartia*) *southwelli* Sewell.

† This species is of doubtful validity.

‡ I originally named this species *tollingeri* ; it has since been pointed out that the correct name should be *tollingeræ*.

*A. (*Acanthacartia*) *chilkaensis* Sewell.
A. (*A.*) *pietschmani* Pesta.
A. longisetosa Brady.†
A. nana Brady.†
Tortanus (*Atortus*) *recticauda* Giesbr.
T. (*A.*) *tropicus* Sewell.
Oithona decipiens Farran.
**O. dissimilis* Lindberg.
O. erythrops Brady.†
O. hamata Rosendorn.
**O. horai* Sewell.
Dioithona alia Kiefer.
**D. indo-gallica* Lindberg.
Paroithona pula Farran.
Oithonopsis farrani Brady.†
Corycæus latissimus Brady.
C. latus Dana.
Corycella brevis Farran.
Sapphirina serrata Brady.

Many of the above species have been taken in brackish-water, and these I have indicated by an asterisk, while one species, *Pseudodiaptomus lobipes*, is an inhabitant of fresh-water. The head of the Bay of Bengal appears to be a region where this penetration from the sea into brackish-water has been particularly active, and this doubtless is associated with the presence in this region of the estuaries of several large rivers, such as the Irrawaddi River, that empties through an extensive delta into the northern end of the Andaman Sea, the Brahmaputra and Ganges rivers that empty through a common delta into the head of the Bay of Bengal, and the Mahanaddi River that has its own delta, connected with the Chilka Lake, at the northern end of the east coast of India, while opening on the east coast of India are the estuaries of the Godaveri and Kistna rivers.

In consequence of the comparatively free interchange that takes place between the eastern part of the Indian Ocean and the Malayan region of the western Pacific Ocean it is probable that some, and perhaps many, of the above species will ultimately be recorded from this latter area ; but from a study of the distribution within the Indian Ocean of those species that are known to occur also in the Malayan region it seems probable that the main trend of dispersal has been from east to west rather than *vice versa*. In the following table I have given the number of surface-living Calanoida that have been taken in the Malay Archipelago and have also been recorded from the Indian Ocean ; and it is clear that as we pass westward there is a gradual falling off in numbers, and a similar

	Number of species that have been taken in —				
Region in which species have probably been evolved.	Malay Archipelago.	South Burma, Andaman and Nicobar Islands.	Ceylon Pearl Banks.	Arabian Sea.	Red Sea.
Malay Archipelago	117	85	71	67	52
S. Burma coast and Andaman and Nicobar Islands	..	16	9	4	4
Ceylon Pearl Banks	..	..	6	3	1

† These species are of doubtful validity.

reduction is seen in the number of species that appear to have been evolved in the different regions of the Indian Ocean itself.

It is somewhat surprising that so few of the species that appear to have originated in the Indian Ocean have been able to penetrate into the Red Sea. Three species have been taken in the Red Sea itself, namely,

Macandrewella chelipes (Giesbrecht),
Oithona fallax Farran,
Sapphirina maculosa Giesbr.,

and two others have been able to pass through the Red Sea and have been recorded from the Gulf of Suez and the Suez Canal, namely,

Pseudodiaptomus salinus Giesbr,.
Acartia (*Odontacartia*) *centrura* Giesbr.

A number of these species that have not, up to the present time, been recorded from further east than the Indian Ocean are also known to occur in the Atlantic Ocean, and have therefore been able to survive the passage in one direction or another round the Cape of Good Hope. Some of these species seem definitely to be Indian and so have passed westwards, doubtless in the branch of the Agulhas Current, to which attention has already been drawn. These species are the following :

Paracalanus nanus Sars.
Pseudodiaptomus serricaudatus T. Scott.
Pseudocyclops obtusatus Grady and Robertson.
Candacia inermis Cleve (= *obtusa* Sars, *rotundata* Wolf.).
Pontella spinipes Giesbr.
Acartia centrura Giesbr.
A. plumosa T. Scott.
Oithona fallax Farran.
O. hamata Rosendorn.
O. pseudofrigida Rosendorn.
O. vivida Farran.
Paroithona parvula Farran.
Corycæus (*Ditrichocorycæus*) *minimus* F. Dahl s.sp.*
C. (*Onychocorycæus*) *latus* Dana (= *indicus* M. Dahl).
Sapphirina maculosa Giesbr.
Ectinosoma normani T. and A. Scott.

In addition to these, a number of species, that seem to be normal inhabitants of the Atlantic Ocean or its offshoot the Mediterranean Sea, have occasionally been reported from the Indian Ocean. Such species are—

Calanus finmarchicus Gunn.,
Ctenocalanus vanus Giesbr.,
Centropages typicus Kröyer,
C. hamatus (Lillj.),

* M. Dahl (1912, p. 128) maintains that this species is confined to the Atlantic Ocean

Euchæta hebes Giesbr.,
Labidocera nerii Krämer,
Pontella atlantica (M. E.),
P. mediterranea (Claus),
Anomalocera patersoni Templ.,
Parapontella brevicornis (Lubb.),

and perhaps to these should be added *Centropages chierchiæ* Giesbr. It is possible that the records of some of these species in the Indian Ocean are due either to incorrect record of their habitat or to faulty identification. A single specimen of *Calanus finmarchicus* Gunn. was taken by the "John Murray" Expedition in the Arabian Sea, and *Anomalocera patersoni* Templ. has been recorded by Thompson (1900) from the region of the Agulhas Current off the east coast of South Africa; but the record of occurrence of *Anomalocera patersoni* Templ., *Pontella mediterranea* and *Parapontella brevicornis* (Lubb.) from the Maldive and Laccadive Archipelagos by Wolfenden (1906) could be explained by accidental mixing of collections from this region and the Atlantic Ocean. On the other hand, it is possible that these stray individuals have been carried eastward from the Atlantic Ocean into the Indian Ocean by a deep current of Atlantic Intermediate water, which, as I shall show later (*vide infra*, p. 522), seems to be responsible for the transference eastward of many deep-dwelling species from one ocean to another; such a transference would seem to be the more probable explanation in the case of *Calanus finmarchicus* Gunn. and *Anomalocera patersoni* Templ., both of which are known to live in the Atlantic Ocean as deep as 750 m., at which depth they would be inhabitants of the north Atlantic intermediate water. *Pontella atlantica* (M. E.) may have been carried eastward in the same deep current; this species has been recorded from the Indian Ocean, Mori (1935) records it off Japan, and Wilson (1942) reports its presence in both north and south regions of the east Pacific area. Its appearance in this latter region may, if we accept the view that the species was in existence in the Tertiary epoch and has remained unchanged ever since, be ascribed to the presence at that time of a direct connection between the Atlantic and Pacific Oceans across what is now Central America. Farran (1926) has suggested that *Centropages chierchiæ* Giesbr. is a Mediterranean species, and that it has been swept out in the outflowing deep current into the Atlantic Ocean and then carried northwards into the Bay of Biscay; it has now been established that this outflowing current of Mediterranean water flows westward and joins the North Atlantic intermediate Current, a branch of which flows eastward past the Cape of Good Hope into the southern part of the Indian Ocean, and can even be traced as far as the south-west region of the Pacific. It seems possible that the occurrence of examples of the Atlantic variety of *Rhincalanus cornutus* at Stas. 135 and 145 in the "Valdivia" collections (*vide* Schmaus and Lahnhofer, 1927), both of which lie to the south and somewhat to the east of the Cape of Good Hope, may be due to the same deep current, for the depth at which these examples were taken was 1500 m. The occurrence of *Labidocera brunescens* (Czern.) off the coast of New South Wales, reported by Dakin and Colefax (1933), may, if confirmed, be attributed to the same deep water movement.

Our knowledge of the Copepod fauna of the Red Sea is due to the work of Giesbrecht (1892, 1897), Steuer (1898), Thompson (1900), A. Scott (1902), Thompson and A. Scott (1903), Cleve (1903) and Schiacchitano (1930).

I have been able to collate references to 111 species that have been taken in this enclosed area :

Nannocalanus minor (Claus).
Canthocalanus pauper (Giesbr.).
Undinula darwini (Lubb.).
U. vulgaris (Dana).
Eucalanus crassus Giesbr.
E. pilcatus Giesbr.
E. subcrassus Giesbr.
E. subtenuis Giesbr.
Rhincalanus cornutus Dana.
R. nasutus Giesbr.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. crassirostris F. Dahl.
P. parvus (Claus).
Acrocalanus gibber Giesbr.
A. gracilis Giesbr.
A. longicornis Giesbr.
A. monachus Giesbr.
Calocalanus pavo (Dana).
C. plumulosus (Claus).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Euchæta concinna Dana.
E. marina (Prestand.).
Macandrewella chelipes (T. Scott).
Centropages calaninus (Dana).
C. elongatus Giesbr.
C. furcatus (Dana).
C. gracilis (Dana).
C. orsinii Giesbr.
C. violaceus (Claus).
Temora discaudata Giesbr.
T. stylifera (Dana).
T. turbinata (Dana).
Pseudodiaptomus salinus (Giesbr.).
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bispinosa Claus.
C. bradyi Wheeler.
C. catula Giesbr.
C. curta Dana.
C. longimana Claus.
C. simplex Giesbr.

C. truncata Dana.
Calanopia elliptica (Dana).
C. minor A. Scott.
Labidocera acuta (Dana).
L. minuta Giesbr.
L. orsinii Giesbr.
L. pavo Giesbr.
Pontella fera Dana.
Pontellopsis krameri (Giesbr.).
Pontellina plumata Dana.
Acartia (*Odontacartia*) *centrura* Giesbr.
A. (*Acartiura*) *clausi* Giesbr.
A. (*Odontacartia*) *erythræa* Giesbr.
A. (*Planktacartia*) *negligens* Dana.
Tortanus (*Tortanus*) *barbatus* Brady (= *denticulatus* Giesbr.).
T. (*T.*) *forcipatus* (Giesbr.).
T. (*T.*) *gracilis* (Brady).
T. (*Atortus*) *recticauda* Giesbr.
Oithona fallax Farran.
O. linearis Giesbr. (= *setigera* Dana).
O. nana Giesbr.
O. plumifera Baird.
O. rigida Giesbr.
O. robusta Giesbr.
O. setigera Dana.
O. similis Claus.
O. simplex Farran.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
O. notopus Giesbr.
O. venusta Philippi.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *longistylis* Dana.
C. (*Ditrichocorycæus*) *asiaticus* F. Dahl.
C. (*D.*) *erythræus* Cleve.
C. (*D.*) *lubbocki* Giesbr.
C. (*Onychocorycæus*) *agilis* Dana (= *gracilicaudatus* Giesbr.).
C. (*O.*) *catus* F. Dahl.

C. (*O.*) *obtusus* Dana (= *catus* F. Dahl).
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gibbulus* Giesbr.
C. (*C.*) *rostratus* Claus.
Sapphirina auronitens Claus—*sinuicauda* Brady.
S. bicuspidata Giesbr.
S. gastrica Giesbr.
S. lactens Giesbr.
S. maculosa Giesbr.
S. metallina Dana.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
Copilia mirabilis Dana.
Ectinosoma melaniceps Boeck.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).
Clytemnestra rostrata (Brady).
C. scutellata Dana.

Farran (1911) has given *Calanus finmarchicus* (Gunn.) as occurring in the Red Sea. I was unable to trace any reference to the occurrence of this species in this locality, and on referring the matter to Mr. Farran he has kindly written to say that it must be a clerical error, committed when tabulating one of the Red Sea lists, and he has asked me to correct this.

Two of the above species appear to be "endemic" in this area, namely *Labidocera orsinii* Giesbr. and *Tortanus* (*Atortus*) *recticauda* Giesbr.; all the other species are known to be inhabitants of the Indo-Pacific region, and a study of the individual species reveals that 107 are known to inhabit this region, and of these as many as 78 have been recorded from the east Pacific area, 23 from the west, but not from the east, Pacific region, and 6 have not been recorded from east of the Indian Ocean. In the following table I have given the total number of species that appear to be indigenous in each of the three areas, and the number that have been recorded from the Red Sea:

Region.	Total number of indigenous species.	Number taken in the Red Sea.	Percentage.
East Pacific region	179	78	44%
West Pacific region	109	23	21%
Indian Ocean	72	6	8%

In comparison with the Indian Ocean, from which we have records of some 270 species, the Copepod fauna of the Red Sea is distinctly poor. At the present day the only entrance for planktonic organisms into the Red Sea appears to be through the Gulf of Aden and the

Strait of Bab-el-Mandeb, for, as Gurney (1927, p. 141) has pointed out, the Copepoda of the Suez Canal afford " no evidence of a southward migration through the Canal," and Munro Fox (1926, p. 39) has also pointed out that " the fact that the majority of the plants present in the canal waters are derived from the Red Sea affords additional evidence that the similar invasion of the canal by erythræan species of sessile animals is conditioned by currents, transporting spores and larvæ from the south to the north." Most of the collections that have been made in the Red Sea were taken in different months of the year, and it is very interesting to note the differences in the various collections. The number of species recorded in the different months are as follows :

Month.	Number of species.
January	73
March	42
April	40
June	37
July–August	29
October	38

Thompson (1939) has shown that " the exchange of water over the sill between the Red Sea and the Gulf of Aden is fundamentally different in the winter and summer months. In the winter, from October to April, there are but two masses of water moving over the 'sill', a very warm surface layer entering the Red Sea from the Gulf of Aden, and a deep outflow of very saline water passing out from the Red Sea. In the summer time there are three bodies of water moving over the 'sill', a wind-driven surface mass of high temperature water flowing out of the Red Sea into the Gulf of Aden, a bottom outflow of very saline water from the Red Sea into the Gulf, and an intermediate low salinity, low temperature inflow from the Gulf of Aden into the Red Sea." It seems probable that the monthly differences in the number of species can be correlated with the in-flowing and out-flowing surface currents ; at the commencement of the winter season in October the number of species is low, 38, but as the current sets in and flows into the Red Sea it will carry with it numerous surface-living species from the Gulf of Aden, and the number of species taken in the Red Sea shows an increase to 73 in January. With the onset of the summer season (May to September) the surface water flows out of the Red Sea, and this may carry with it species that have been swept in during the winter months, so that the number of species taken in the Red Sea falls to a minimum of 29 in July–August. There are as many as 37 species which have only been recorded from the Red Sea during the winter season, namely :

Nannocalanus minor (Claus).
Undinula darwini (Lubb.).
Eucalanus subtenuis Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
Acrocalanus longicornis Giesbr.
Calocalanus plumulosus (Claus).

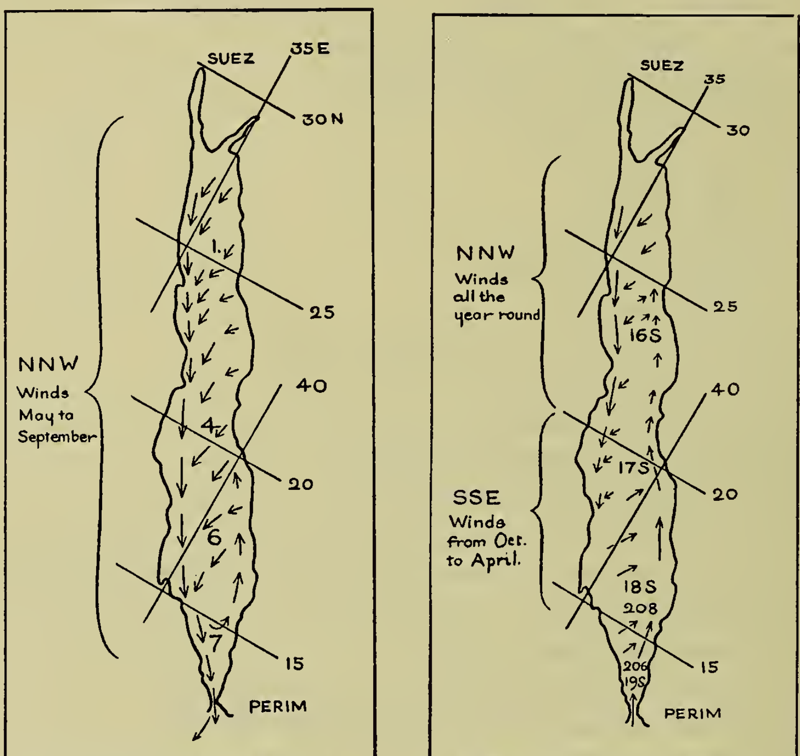
Clausocalanus arcuicornis (Dana).
Euchæta marina (Prestand.).
Centropages calaninus (Dana).
C. gracilis (Dana).
Candacia bradyi Wheeler.
Calanopia minor A. Scott.
Labidocera minuta Giesbr.
Pontella fera Dana.
Pontellina plumata Dana.
Acartia (*Odontacartia*) *centrura* Giesbr.
Tortanus (*Tortanus*) *gracilis* (Brady).
Oithona linearis Giesbr.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana.
C. (*C.*) *elongatus* F. Dahl.*
C. (*C.*) *speciosus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Ditrichocorycæus*) *erythræus* Cleve.
C. (*D.*) *lubbocki* Giesbr.
C. (*Onychocorycæus*) *gracillicaudatus* Giesbr. (= *agilis* Dana).
C. (*O.*) *obtusus* Dana.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gibbulus* Giesbr.
Sapphirina auronitens Claus—*sinuicauda* Brady.
S. gastrica Giesbr.

Certain other species appear to be even more restricted in their appearance in the Red Sea and have been recorded only from the extreme south end ; thus *Candacia bispinosa* Claus has been taken in this area in October and January, *Candacia simplex* Giesbr. in January and April, *Euchæta concinna* Dana only in October ; and the following species only in the month of January :

Eucalanus crassus Giesbr.
E. pileatus Giesbr.
Acrocalanus monachus Giesbr.
Lucicutia flavicornis (Claus).
C. longimana Claus.
Candacia æthiopica Dana.
Sapphirina ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.

* *Corycæus elongatus* F. Dahl is almost certainly an immature stage of either *Corycæus crassiusculus* Dana or *C. speciosus* Dana.

A further factor that must have a profound influence on the distribution of the surface Copepoda within the limits of the Red Sea is the seasonal difference to be found in the general trend of the surface currents. Thompson (1939, p. 86) has given two charts showing the set of these currents during the summer (May to September) and winter (October to April) months, and he indicates that in the southern half of the Red Sea there is a counter-clockwise movement of the surface water, an inflowing current from the Gulf of Aden passing northwards on the east side and then turning round and passing south-



Showing the positions of the stations used in sections 2,3,4,5 & 6 The surface currents which would be expected from May to September are indicated by arrows.

Showing the positions of the stations used in sections — 7, 8, 9 & 10. The surface currents which would be expected from October to April are indicated by arrows.

TEXT-FIG. 85.

wards on the west side, but that the northern limit of the counter-clockwise movement lies in about lat. 20° N. during the summer months and in lat. 25° N. during the winter season, while to the north of this the whole of the surface water is moving southwards. This southward movement of the surface water must severely impede the passage of any epi-planktonic organisms northwards from the southern half of the Red Sea, and will tend to prevent altogether the spread of these organisms into the Gulf of Suez (*vide* Fig. 85).

The absence, or only temporary occurrence, of so many species, which are widespread throughout the Indo-Pacific region, seems to indicate that conditions in the Red Sea are not favourable to their existence in that habitat. Stubbings (1939, p. 147) has pointed out that during the winter season the inflowing current into the Red Sea from the Gulf of Aden " carries the Pteropoda into the Red Sea, where they come into contact with the

more saline and warmer Red Sea water, which proves fatal to them. Their shells sink down to form the deposit of Pteropod ooze met with on the north-west side of the "sill"; and he gives the following table showing the rapid increase in the percentage of Pteropod shells in the deposit as one passes from the Gulf of Aden into the Red Sea:

Region.	Station.	Deposit.	Pteropod shells. % deposit.	Pteropod shells. % remains.
Gulf of Aden	12	cs. s. sh.	..	..
S.E. side of "sill"	9	r., s.	..	..
Top of "sill"	204	gn. m. Pt. sh.	0·4	1·5
N.W. side of "sill"	7	s., Pt. sh.	..	16·9
Ditto	206	Pt. oz.	8·0	60·5
,,	207	Pt. oz.	8·1	65·4

Clearly we have here a region of admixture of waters of different characteristics that is extremely fatal to the Pteropoda, and it would appear probable that it is equally fatal to a large number of Copepoda; this would account for the absence in the Red Sea of more than half the number of species that are known to inhabit the Indian Ocean.

As we pass northwards to the region of the Gulf of Suez the copepod fauna gets even more scanty; a study of the works of A. Scott (1902), Thompson and A. Scott (1903), Gurney (1927) and Nicholls (1944*b*) gives the following species whose presence in this area can be relied on:

Canthocalanus pauper (Giesbr.).
Undinula darwini (Lubb.).
Paracalanus aculeatus Giesbr.
P. crassirostris F. Dahl.
P. parvus Giesbr.
Acrocalanus gibber Giesbr.
Calocalanus pavo (Dana).
C. plumulosus (Claus).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Centropages calaninus (Dana).
C. furcatus Dana.
Pseudodiaptomus salinus (Giesbr.).
Temora discaudata Giesbr.
T. stylifera (Dana).
Pseudocyclops reductus Nicholls.
Lucicutia flavicornis (Claus).
Calanopia elliptica (Dana).
Labidocera acuta (Dana).
L. minuta Giesbr.
L. pavo Giesbr.
Acartia (Acartiura) clausi Giesbr.
A. (Odontacartia) centrura Giesbr.

A. (*O.*) *erythræa* Giesbr.
A. (*Planktacartia*) *negligens* Dana.
Tortanus (*Tortanus*) *gracilis* (Brady).
Oithona nana Giesbr. (southern form, *vide* Gurney, 1927, p. 159).
O. plumifera Baird.
O. similis Giesbr.
O. simplex Farran.
Oncæa media Giesbr.
O. minuta Giesbr.
O. venusta Philippi.
Lubbockia squillimana Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana.
C. (*Ditrichocorycæus*) *asiaticus* F. Dahl.
C. (*D.*) *erythræus* Cleve.
C. (*Corycella*) *gibbulus* Giesbr.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella graciltis (Dana).
Clytemnestra scutellata Dana.

A few other species have been recorded by Thompson and A. Scott (1903) and A. Scott (1902) from the Gulf of Suez or the neighbouring part of the Red Sea. Some of these may have reached this area from the Indian Ocean and the Red Sea, since they have been reported from these latter regions ; these species are—

Oncæa mediterranea Claus.
O. notopus Giesbr.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Onychocorycæus*) *obtusus* Dana.

Other species that have been recorded by the above authors are, however, open to doubt. In both these collections the mode of capture was the same : a fine muslin bag was attached to a bath-room tap and the water was allowed to strain through it. I have already pointed out that this water does not come directly from the sea, but is first pumped into tanks from which the baths are supplied. Several species were obtained while the vessel was passing through the Suez Canal from Port Said to Suez, and it thus seems clear that the water sampled during this passage was almost certainly obtained from the eastern part of the Mediterranean. It is not surprising therefore to find in their collections certain species that are known to be inhabitants of the Mediterranean Sea or the Atlantic Ocean, namely,

Pseudocalanus elongatus (Boeck) (= *minutus* Kröyer),
Temoropia mayumbæensis (T. Scott),
Acartia longiremis (Lillj.),
A. (*Paracartia*) *dubia* T. Scott (? = *latisetosa* (Kricz.),
Corycæus (*Onychocorycæus*) *ovalis* Claus,

but these cannot be regarded as part of the fauna of the Suez Canal and the Gulf of Suez.

Very few species appear to have had their origin in the Gulf of Suez and the Suez canal: the total number of these appears to be five, namely,

Pseudocyclops umbraticus Giesbr.,
P. reductus Nicholls,
Calanopia media Gurney,
Acartia (*Acanthacartia*) *fossæ* Gurney,
Corycæus (*Onychocorycæus*) *medius* Gurney,

while two others seem to have originated in the Red Sea, namely,

Labidocera orsinii Giesbr.
Tortanus (*Atortus*) *recticauda* A. Scott.

Regarding the possibility of species making their way through the Suez Canal into the Mediterranean Sea, it has been well established that several of the more powerful swimmers, such as fish, or the active bottom-dwelling crustacea have been able to survive the passage and have penetrated into the Mediterranean Sea; but with the planktonic Copepoda the picture is a different one. Munro Fox (1926, p. 24) remarks, "the all-important fact from the point of view of animal distribution . . . is that for 10 months of the year—from October to July—the high density of the Bitter Lake water extends along the Canal as far north as kilometre 10, near Port Said. In the remaining months of August and September, on the contrary, the low-density water of Port Said penetrates into the Canal beyond Lake Timsah. This can only mean that from October to July a current flows from the Great Bitter Lake to the North, while in August and September the direction of the current is reversed and it flows to the south." Munro Fox (*loc. cit.*, p. 26) also points out that "currents are normally absent in the Bitter Lakes, except within 5 kilometres of the southern end of the Little Bitter Lake, where the tidal stream from Suez may still be felt. . . . Although Red Sea animals and plants can be transported rapidly by the tidal currents as far as the Little Bitter Lake, their further advance to the northern end of the Great Lake must be slow." A further check to "migration" may be the high salinity that still prevails in the Great Bitter Lake, which ranges from 48·5 to 52·2°/₀₀ at the present day and which, when the canal was first opened, was as high as 68·9°/₀₀.

Munro Fox (in Gurney, 1927, p. 171) in his table of distribution of the planktonic Copepoda within the limits of the canal shows that there is a steady fall in the numbers present as we pass from Suez Bay and Port Taufiq, with 18 and 19 species respectively, to the Bitter Lakes with 15, Lake Timsah with 13 and Kantara at Km. 45 only 4; further north the number present rises again to 10 at Km. 35 and 11 at Port Said, but this rise is due to the entry of species from the Mediterranean Sea, such as—

Paracalanus parvus Claus, northern form, *borealis* Wolfend.
? *Temora stylifera* (Dana).
? *Acartia* (*Acartiura*) *clausi* Giesbr.
A. (*Paracartia*) *latisetosa* (Kriczagin).
Oithona nana Giesbr., typical form.
Corycæus (*Ditrichocorycæus*) *brehmi* Steuer.
Centropages ponticus Karawiew.
? *Euterpina acutifrons* (Dana).
? *Oncæa media* Giesbr.

Thanks to the work of the following authors, Brady (1878–81, 1883), Thompson (1887, 1888, 1893, 1895, 1896, 1897, 1900), Thompson and A. Scott (1897, 1903), T. Scott (1894, 1897–1905, 1912, 1914), Sars (1901–03, 1903–11, 1913–18, 1919–21, 1925), Cleve (1900, 1901, 1904), Farran (1903, 1905, 1908, 1911, 1926, 1929), Giesbrecht (1892), Pearson (1906), van Breemen (1908), Wolfenden (1904, 1911), Norman and T. Scott (1906), Esterly (1911), Sharpe (1911), Dahl (1912), Pesta (1916), Candeias (1929), Steuer (1923, 1926), Wheeler (1901), Willey (1919), Wilson (1932*a* and *b*, 1942) and others, our knowledge of the Copepod fauna of the Atlantic Ocean is more complete than that of the other two great oceans, Pacific and Indian, and I have been able to collate records of no less than 138 warm-water epi-planktonic species from the south temperate and tropical regions of the South Atlantic Ocean. In this area we have a great counter-clockwise movement of the surface water, and the whole region corresponds to a part of Steuer's zoo-geographical tropical Atlantic region and his southern sub-tropical Atlantic sub-region. The Indo-Pacific species present in this area are as follows :

***Nannocalanus minor** (Claus).
***Canthocalanus pauper** (Giesbr.)
***Undinula darwini** (Lubb.).
***U. vulgaris** (Dana).
***Eucalanus crassus** Giesbr.
***E. monachus** Giesbr.
***E. mucronatus** Giesbr.
***E. pileatus** Giesbr.
***E. subcrassus** Giesbr.
***E. subtenuis** Giesbr.
***Rhincalanus cornutus** Dana.
***Mecynocera clausi** Thompson.
***Paracalanus aculeatus** Giesbr.
***P. crassirostris** F. Dahl.
***P. parvus** (Claus).
Acrocalanus longicornis Giesbr.
Calocalanus contractus Farran.
***C. pavo** (Dana).
C. plumulosus (Claus).
***Clausocalanus arcuicornis** (Dana).
***C. furcatus** (Brady).
Pseudocalanus minutus Kröyer (= *elongatus* (Boeck)).
***Euchæta acuta** Giesbr.
***E. concinna** Dana.
***E. marina** (Prestand.).
E. philippi Brady.†
***Scolecithrix danæ** (Lubb.).
Scolecithricella bradyi (Giesbr.).
S. dentata (Giesbr.).
***S. minor** (Brady).
***Centropages brachiatus** (Dana).

† This species is of doubtful validity.

*C. *calaninus* Dana.
*C. *furcatus* (Dana).
C. gracilis (Dana).
C. violaceus Brady.
**Pseudodiaptomus serricaudatus* (T. Scott).
**Temora longicornis* (Mull.).
*T. *stylifera* (Dana).
T. turbinata (Dana).
**Lucicutia flavicornis* (Claus).
C. æthiopica Dana.
*C. *bipinnata* Giesbr.
Candacia bispinosa Claus.
*C. *curta* Dana.
C. longimana Claus.
*C. *pachydactyla* Dana.
C. pectinata Brady.
C. inermis Cleve (= *rotundata* Wolfend., *obtusa* Sars).
C. simplex Giesbr.
*C. *truncata* Dana.
*C. *varicans* Giesbr.
**Labidocera acuta* (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
L. wollastoni (Lubb.).
**Pontella fera* Dana.
*P. *securifer* Brady.
P. spinipes Giesbr.
Pontellopsis perspicax (Dana).
P. regalis (Dana).
P. villosa Brady.
**Pontellina plumata* Dana.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Acanthacartia*) *tonsa* Dana.
A. (*A.*) *plumosa* T. Scott.
A. (*Odontacartia*) *centrura* Giesbr.
*A. (*Planktacartia*) *danæ* Giesbr.
A. (*P.*) *negligens* Dana.
A. laxa Dana.†
A. denticornis Brady.†
Oithona atlantica Farran.
O. attenuata Farran.
O. brevicornis Giesbr.
*O. *fallax* Farran.
O. hamata Rosendorn.
*O. *nana* Giesbr.

† This species is of doubtful validity.

**O. plumifera* Baird.
O. pseudofrigida Rosendorn.
O. robusta Giesbr.
O. setigera (Dana).
**O. similis* Claus.
O. simplex Farran.
O. tenuis Rosendorn.
O. vivida Farran.
Paroithona parvula Farran.
**Oncæa conifera* Giesbr.
**O. media* Giesbr.
**O. mediterranea* Claus.
**O. subtilis* Giesbr.
**O. venusta* Philippi.
**Lubbockia squillimana* Claus.
Corycæus (*Corycæus*) *clausi* F. Dahl.
*? *C.* (*C.*) *crassiusculus* Dana.
**C.* (*C.*) *speciosus* Dana.
**C.* (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
**C.* (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
**C.* (*Urocorycæus*) *furcifer* Claus.
C. (*U.*) *lautus* Dana.
C. (*Ditrichocorycæus*) *minimus* F. Dahl.
C. (*Onychocorycæus*) *agilis* Dana.
C. (*O.*) *catus* F. Dahl.
C. (*O.*) *giesbrechti* F. Dahl.
C. (*O.*) *latus* Dana.
**C.* (*O.*) *obtusus* Dana.
C. (*Corycella*) *curtus* Farran.
**C.* (*C.*) *gracilis* Dana.
**C.* (*C.*) *rostratus* Claus.
**Sapphirina angusta* Dana.
**S. auronitens* Claus—*sinuicauda* Brady.
S. gastrica Giesbr.
S. intestinata Giesbr.
**S. iris* Dana.
S. lactens Giesbr.
S. maculosa Giesbr.
S. metallina Dana.
**S. nigromaculata* Claus.
**S. opalina* Dana—*darwini* Haeckel.
**S. ovatolanceolata* Dana—*gemma* Dana.
**S. scarlata* Giesbr.
S. stellata Giesbr.

Copilia lata Giesbr.
C. mediterranea (Claus).
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea (Haeckel).
Ectinosoma melaniceps Boeck.
E. normani T. and A. Scott.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
**Macrosetella gracilis* (Dana).
Miracia efferata Dana.
Clytemnestra rostrata (Brady).
C. scutellata Dana.
**Ægisthus aculeatus* Giesbr.
**Æ. mucronatus* Giesbr.

If, as seems probable, the majority of these species have been carried westward from the Indo-Pacific region to the Atlantic Ocean by the surface current round the Cape of Good Hope, one would expect to find that a large proportion of them might, at one time or another, have been taken in the Cape region.

Dahl (1894) put forward the view that at the southern point of Africa a cold Atlantic current meets a warm Indo-Pacific current, so that a mixture and an exchange of the respective tropical forms cannot take place, and that since the connection between the Atlantic and Pacific Oceans was interrupted in the Tertiary period by the upheaval of Central America, similar and yet somewhat divergent forms have developed in the two oceans. Meissenheimer (1905) and others have called attention to the manner in which the warm water of the Agulhas Current from the Indian Ocean meets the cool water of the West Wind Drift, and is bent first southwards and then eastwards to flow parallel with it, while a branch of the cool West Wind Drift turns northwards along the west coast of Africa and becomes mixed with cold upwelling water to form the Benguela Current, that in its turn swings towards the north-west and becomes the South Atlantic Equatorial Current. Steuer (1928) maintains that while the upwelling water renders the development of a rich plankton possible, the change from a warm to a luke-warm temperature brought about by the upwelling and the admixture of cool water causes many steno-thermic planktonic organisms to die out. This admixture of cool surface water and cold upwelling water undoubtedly forms a barrier to the westerly extension of some species, and doubtless is one factor in the preservation of the differences that exist between the plankton of the Indo-Pacific and Atlantic regions, but its effects should not be over-rated. Cleve (1904) studied the Copepoda of this region, and in the Introduction to his paper attempted to correlate the water movements with the distribution of the various species. He expressed the view that "it might be expected that the waters of the Agulhas Bank would possess a kind of plankton different from that of the waters east of South Africa," and he concluded from his researches that this had been proved to be the case. He drew attention to the manner in which the mixed waters of the Agulhas Current and the West Wind Drift flow eastward across the southern part of the Indian Ocean, sending a branch northwards

along the west coast of Australia and then, after crossing the Pacific Ocean, " a very mighty one when it meets the south end of America or the north-going Humboldt Current " ; to this he attributed the presence off South Africa of numerous species that are common to that region and to the west coast of South America. Cleve also put forward the view that " the waters of the temperate Atlantic in the Northern Hemisphere originate, not in the Gulf Stream, but from the Benguela Current, which is supposed to pass as an undercurrent below the waters of the tropical Atlantic " ; and to this he attributed the fact that " of the Copepoda found south and west of the Cape Colony a considerable number also occur in the Northern Hemisphere, north of a line traced from the Newfoundland Banks to the Azores and the Cape Verde Islands, some so far to the north that they pass through the Faröe Channel and reach the coasts of Scandinavia." Unfortunately Cleve does not discriminate between those species that live in the upper levels and thus inhabit the water of the Agulhas and Benguela currents and those that occur at considerable depths, where they would be quite unaffected by movements of the surface water ; nor to-day will anyone agree that the water of the Benguela Current flows northwards beneath the warm water of the tropical region of the Atlantic.

Michaelis (1923) has shown that a branch of the Agulhas Current flows westward from the Indian Ocean round the Cape of Good Hope into the Atlantic Ocean. Stephenson (1944), from his study of the intertidal fauna and flora of the region of the Cape of Good Hope, concludes that as one passes from east to west " the most rapid disappearance of species takes place as the mean annual temperature falls distinctly below 20° C." Steinitz (1929) has pointed out that in the summer month of February in the South Hemisphere the isotherm of 20° C. runs about 2 degrees of latitude to the south of the southernmost point of South Africa, and in consequence temperature offers no bar during this season to the free admixture of the warm-water plankton of the Indian and Atlantic Oceans. Schott (1935) confirms this, and points out that this westerly branch of the Agulhas Current flows against the prevailing wind, which, during the greater part of the year, blows from the west ; and still more recently Deacon (1937, p. 75) also agrees that " a small portion of the (Agulhas) current passes round and over the (Agulhas) Bank and turns towards the north round the Cape of Good Hope." The charts published by the Koninklijk Nederlandsch Meteorologische Instituut (1924–30) show that this westerly flow of water from the Agulhas Current to the Benguela Current is absent during the months June–August ; it commences to flow, though to a slight extent only, in September–November, and reaches its maximum in February–March, when it reaches a velocity of 5·0–9·9 miles per day, and then dies away again. The isotherms of the surface water show that as the water moves westward its temperature falls to some extent—

In	December	from	20·0° C.	to	17·5° C.
,,	February	,,	22·5° C.	,,	20·0° C.
,,	April	,,	22·0° C.	,,	17·5° C.
,,	June to November	,,	20·0° C.	,,	15·0° C.

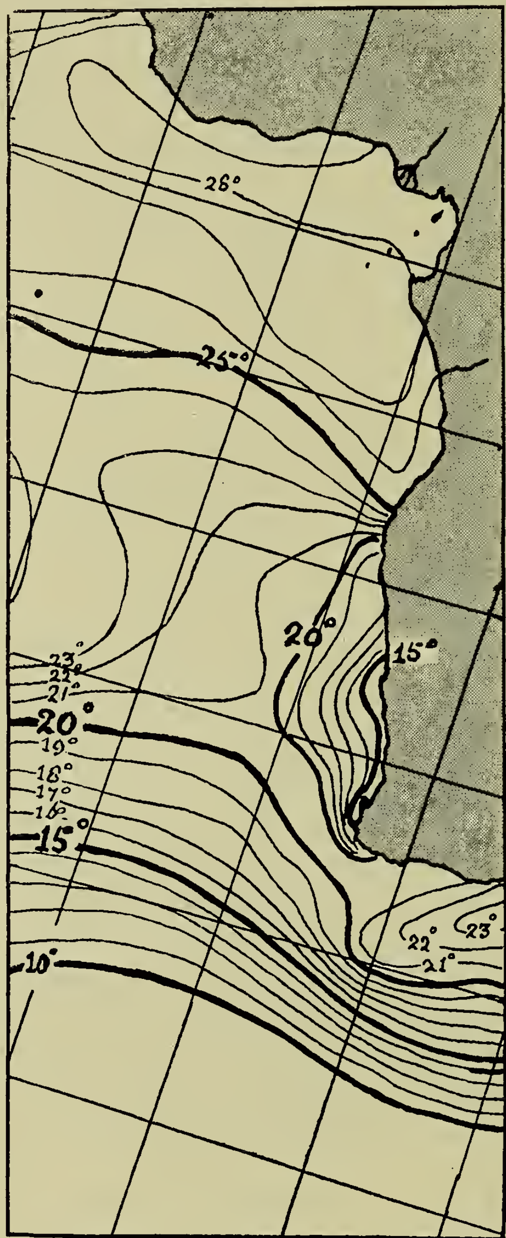
Thus during the earlier part of the year, from December to April, epi-planktonic organisms that are swept westward from the Indian Ocean into the Atlantic will experience a fall of only 2·5° C., and it is during these months that the effect of the North-east Monsoon will be greatly to increase the strength of the Agulhas Current ; it seems probable

that only those species that are least resistant and most susceptible to temperature changes will materially be affected. Much will, however, depend on the position in the temperature scale of the critical temperature below which individuals of the warm-water species are unable to breed; if, as suggested by Stephenson, this lies at about 20° C., the ability to get from one ocean to the other will to some, and perhaps to a great extent, be dependent on the length of time that temperatures above this are to be found off the southern point of Africa; the data given above suggest that such a condition only persists for a relatively short period, since in both December and April the water masses get cooled to about 17·5° C. Marchand (1932) has shown that in December, 1930, the temperature of the sea water at Cape Agulhas was 20·0° C., but that to the west of this and as far up the West African coast as Walvis Bay the surface temperature was considerably less, being as low as 11·6° C. at Port Nolluth. But this low temperature is a feature of the inshore water and is a result of the upwelling of cold water; further seaward the water of the Atlantic Ocean has a temperature of over 15° C. and the isotherm of this temperature runs from east to west well to the south of the Cape region, though no water of 20° C. gets much further than the longitude of Port Elizabeth or 24° E. In the month of February, according to Schott (1902, pl. viii) the 20° isotherm runs well to the south of the Cape, and between the cool water of the West Wind Drift and the inshore cold area of upwelling water of the Benguela Current there is a wide warm-water corridor in which the temperature is at least 20° C. on the surface (*vide* Text-fig. 86). If, however, the critical temperature is, as I have suggested above (*vide supra*, p. 343), nearer to 15° C., there will be, so far as this factor is concerned, little or no obstruction to the passage westward of surface-living species, since the 15° C. isotherm runs at all seasons of the year well to the south of the Cape, and the extent to which the passage from the Indian Ocean to the Atlantic can be made will depend for the most part on the amount of water that is flowing in this direction and the degree of eddy movement and consequent mixing that takes place between the Agulhas and Benguela Currents. It is possible, however, that in times past the facilities for the transport of warm-water planktonic organisms from east to west were greater owing to the sea temperature being somewhat higher than it is to-day. Stanley Gardiner (1931, p. 159) has called attention to the fact that in latitudes to the south of about 17°–20° near the southern limit of coral-reef formation, the reefs at the present time appear to be undergoing a process of regression, leaving to seaward at a depth of about 30–40 fathoms a broad shelf, and he suggests that these reefs are being removed by erosion, and that "the only cause of such removal or regression of reefs is a lowering of the temperature of the sea such as would kill the growing organisms which cover them, and it is noticeable that all these reefs with shelves are situated near the line of ocean temperature critical to reef corals. If temperature is the cause of their regression, they are explicable on the supposition of a still actively progressing glacial period in the southern hemisphere."

Steuer (1933) thinks that it is possible that in certain years the barrier between the Indian and Atlantic faunas at the southern end of Africa is broken down, but he adds, "nevertheless it appears to come to this, that Indian forms in the long run do not survive in the Atlantic." In reaching this decision he appears to me to have been over-influenced by the presence in the two regions of distinct races of the species *Rhincalanus cornutus*, f. *typicus* in the Indo-Pacific region and f. *atlanticus* in the Atlantic Ocean.

At the commencement of the Tertiary Epoch there was a direct connection through the tropical region between the Indo-West Pacific area and the Atlantic Ocean by means of

the Tethys Sea. In Miocene times this highway was finally closed by the elevation of the Alpine-Himalayan mountain range ; but it may be argued that the presence of so many species in these two regions at the present time is attributable to this ancient connection. If, however, this were the true explanation I feel that the differences between



Text-fig. 86.—The temperature of the surface water off the South-west coast of Africa in February. (After G. Schott, 1902.)

the two faunas would be far greater than it is, and I believe that of the 138 species listed above, by far the greater number have been carried in more recent times by currents round the Cape of Good Hope from east to west. If this be the case one would expect to find that a large proportion of the species present on the two sides of South Africa have at one time or another been taken in the Cape region. Comparatively little work has been

carried out in this area, but, even so, a number of these species have been taken, and I have indicated these in the above list by an asterisk. It is, I think, justifiable to conclude that in the past a number of the more hardy species have managed to survive the comparatively sudden transition from the warm water of the Agulhas Current to the cool water of the Benguela Current and thus have reached the Atlantic Ocean. It is not necessary, however, to assume that such a transference of species westwards is going on continually, and it is possible that only under exceptional meteorological conditions, such as an increase in the strength of the north-east monsoon wind, does sufficient warm water find its way westward to minimize the sudden fall of temperature in the surface water, and so enable plankton to be swept round the Cape of Good Hope into the Atlantic Ocean in a viable condition.

In a few instances this transfer from east to west appears to have been accompanied by slight structural changes that have given rise to separate Indo-Pacific and Atlantic forms of the same species ; such a change has been brought about in the following species :

Indo-Pacific form.	Atlantic form.
Rhincalanus cornutus f. *typicus* Dana	*Rhincalanus cornutus* f. *atlanticus* Schmaus.
Corycæus minimus indicus M. Dahl.	*Corycæus minimus minimus* F. Dahl.
Paracalanus parvus (Claus), f. *indicus* Wolf.	*Paracalanus parvus*, f. *borealis* Wolf.
? *Oithona nana* Giesbr., southern form	*Oithona nana*, northern form.
Corycæus (*Corycella*) *rostrata* Claus	*Corycæus* (*Corycella*) *rostrata* var. *longa* Klevenhusen.

Cleve (1901) attempted to define certain types of plankton that are to be found in different regions of the Atlantic Ocean, and to some extent he further attempted to correlate these types with the known movements of the surface water ; he recognized one such type, which he termed "Desmoplankton," as prevailing throughout the whole of the tropical and temperate region of the South Atlantic between Africa and South America and in the Equatorial Current. A second such type, which he termed "Styliplankton," constitutes the plankton of the Gulf Stream water and has a range of distribution from the west of South Africa, the Benguela Current and the Gulf of Guinea, and further to the north is found in the eastern part of the North Atlantic in the region of the Cape Verde, Canary and Azores Islands and at the mouth of the English Channel. Yet another type he termed "Trichoplankton," and this is characteristic of the region between Spitzbergen and Greenland, and is carried westward round Cape Farewell and up the west coast of Greenland, and so into the Labrador Current and down the east coast of North America as far as New York. Since that date a considerable amount of work has been carried out on the correlation of distribution of planktonic organisms and the surface currents.

Assuming that these 138 Indo-Pacific species have been swept westward from the Indian Ocean past the Cape of Good Hope into the Atlantic Ocean, their subsequent distribution will clearly depend on the surface circulation in this latter area. From the Benguela Current these organisms will be carried on into the South Equatorial Current, and so be transported across the Atlantic towards the north-east corner of South America, opposite which this current divides into two main streams. One of these branches turns in a south-

westerly direction and runs parallel to the Brazilian coast, where it is known as the Brazil Current (*vide* Chart I). In about lat. 30° S. this current swings away from the coast and becomes separated from it by the cold northwardly-flowing Falkland Island Current. Still further south in about lat. 40° S. the Brazil Current is deflected sharply to the east and flows back again across the Atlantic basin parallel to the West Wind Drift, and between these two masses of water lies the South Atlantic sub-tropical convergence zone. Off the south-west corner of the Cape the current again swings to the north-east and joins the Benguela Current. This great counter-clockwise movement of the surface-water comprises the geographical area that Steuer (1933, p. 293) terms the Southern Sub-tropical Atlantic sub-region.

Our knowledge of the Copepod fauna of the western part of the South Atlantic is still very incomplete ; but the investigations of Brady (1883), F. Dahl (1894*a*), T. Scott (1912), Farran (1929) and Klevenhusen (1933) have recorded the following species in this area :

Nannocalanus minor (Claus).
Undinula darwini (Lubb.).
U. vulgaris (Dana).
Eucalanus crassus Giesbr.
E. subcrassus Giesbr.
E. vadicola F. Dahl.
Rhincalanus cornutus (Dana), f. *atlantica* Schmaus.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. crassirostris F. Dahl.
P. parvus (Claus).
Acrocalanus longicornis Giesbr.
Calocalanus pavo (Dana).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Ctenocalanus vanus Giesbr.
Euchæta marina (Prestand.).
Scolecithrix danæ (Lubb.).
Drepanopus forcipatus Giesbrecht.
Centropages calaninus (Dana).
C. furcatus (Dana).
C. violaceus (Claus).
Pseudodiaptomus acutus (F. Dahl).
P. gracilis (F. Dahl).
P. marshi Wright.
P. richardi (F. Dahl).
Temora stylifera (Dana).
Lucicutia flavicornis (Claus).
Candacia bipinnata Giesbr.
C. bispinosa Claus.
C. curta Dana.
C. pachydactyla Brady.

C. simplex Giesbr.
Calanopia americana F. Dahl.
Labidocera acutifrons (Dana).
L. braziliense Farran.
L. detruncata (Dana).
L. fluviatilis F. Dahl.
L. nerii (Kröyer).
Pontella patagoniensis (Lubb.).
P. securifer Brady.
P. spinipes Giesbr.
Pontellopsis brevis (Giesbr.).
P. perspicax (Dana).
P. regalis (Dana).
P. villosa Brady.
Pontellina plumata Dana.
A. (*Acanthacartia*) *giesbrechti* F. Dahl.
Acartia (*Planktacartia*) *danæ* Giesbr.
A. (*P.*) *negligens* Dana.
A. (*Odontacartia*) *lilljeborgi* Giesbr.
A. denticornis Brady.
Oithona amazonica Burckhardt.
O. minuta T. Scott.
O. plumifera Baird.
O. setigera (Dana).
O. simplex Farran.
O. similis Claus.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. venusta Philippi.
O. venusta var. *venella* Farran.
Corycæus (*Corycæus*) *clausi* F. Dahl.
C. (*C.*) *crassiusculus* Dana.*
C. (*C.*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *furcifer* Claus.
C. (*U.*) *lautus* Dana.
C. (*Ditrichocorycæus*) *amazonicus* F. Dahl.
C. (*D.*) *minimus* F. Dahl, f. *uncinatus* Klevenhusen.
C. (*Onychocorycæus*) *giesbrechti* F. Dahl.

* M. Dahl (1912, p. 129) maintains that *Corycæus crassiusculus* is an Indo-Pacific species and does not occur in the Atlantic Ocean, where it is replaced by *Corycæus clausi*. Farran (1929, p. 292) notes that the specimens examined by him from New Zealand were intermediate between *crassiusculus* and *clausi*, and it seems doubtful if the distinction between these two species can be maintained.

C. (*O.*) *latus* Dana.
C. (*O.*) *obtusus* Dana.
C. (*O.*) *ovalis* Claus.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. intestinata Giesbr.
S. iris Dana.
S. lactens Giesbr.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
Copilia lata Giesbr.
C. mirabilis Dana.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Miracia efferata Dana.

Of these 93 species no less than 71 (or 72 if we include *Corycella gracilis*, the eastern records of which appear to be open to doubt) have been recorded from, and are widespread inhabitants of, the Indian Ocean, and 43 have been recorded from the region of the Cape of Good Hope and 36 in the Gulf of Guinea. Two species, namely, *Drepanopus forcipatus* and *Acartia lilljeborgi* have in all probability been carried eastward from the south Pacific area in the West Wind Drift past Cape Horn and then have been swept northwards up the American coast in the Falkland Islands Current (*vide supra*, p. 405).

A certain number of species that have been recorded from this region of the east coast of South America appear to be indigenous; some of these are marine in their habitat, namely:

Calanopia americana F. Dahl.
Labidocera braziliense Farran.
Pontella patagoniensis (Lubb.).
Pontellopsis brevis (Giesbr.).

Others appear to have evolved in the brackish water of the great river estuaries, namely:

Eucalanus vadicola F. Dahl.
Pseudodiaptomus acutus (Dahl).
P. gracilis (Dahl).
P. marshi Wright.
P. richardi (Dahl).
Labidocera fluviatilis Dahl.
Oithona amazonica Burckhardt.
Corycæus (*Ditrichocorycæus*) *amazonicus* F. Dahl.
Acartia (*Acanthacartia*) *giesbrechti* F. Dahl.

None of these has as yet been recorded outside the region of the east coast of South America, with the single exception of *Calanopia americana*: as Farran (1929, p. 211) has pointed out, this species is confined to the west side of the Atlantic, but its distribution is not so restricted as that of the others; it was originally taken in the estuary of the Amazon River, but it has since been recorded by A. Scott (1909, p. 181) from Bermuda in the North Atlantic, and by Jespersen (1940, p. 67) from Iceland in lat. 62° 40′ N., long. 19° 05′ W. For the rest it seems probable that they are endemic on the east coast of South America.

We have already seen that in about lat. 35°–40° S. the water mass of the Brazil Current swings eastward and runs across the South Atlantic Ocean parallel to and on the north side of the West Wind Drift; a similar arrangement of the current systems is found in the Indian Ocean, where the Agulhas and Madagascar Currents bend eastward, and again in the south-west area of the Pacific Ocean, where the East Australian Current swings eastward past New Zealand. In all three oceans between these various current systems and the West Wind Drift lies the Sub-tropical Convergence Zone, and though there is, of necessity, a certain amount of mixing of the two water masses along the line, the transition from warm to cool conditions appears to form a barrier to the southward extension of a number of species. In all three oceans it is, however, possible for the more hardy species to survive transference across the Convergence Zone and so to become inhabitants of the West Wind Drift. As this great current system is circum-terrestrial, it seems probable that all species found in it will equally possess a circum-terrestrial distribution, and I have assumed that this is so. The species that have so far been recorded from the region of the West Wind Drift are the following:

Nannocalanus minor (Claus).
Undinula darwini (Lubb.).
Eucalanus longiceps Matthews (= *acus* Farran)
E. subtenuis Giesbr.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
Calocalanus pavo (Dana).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
C. pergens Farran.
Ctenocalanus vanus Giesbr.
Microcalanus pygmæus Sars.
Euchæta marina (Prestand.).
Scolecithricella minor (Brady).
Centropages brachiatus (Dana).
C. violaceus (Claus).
Temora turbinata (Dana).
Candacia cheirura Cleve.
C. truncata Dana.
Labidocera acutifrons (Dana).
Acartia (*Acartiura*) *clausi* Giesbr.

A. (*Planktacartia*) *danæ* Giesbr.
Oithona plumifera Baird.
O. similis Claus.
Oncæa conifera Giesbr.
O. curvata Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. notopus Giesbr.
Conea rapax Giesbr.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*Uricorycæus*) *furcifer* Claus.
C. (*Corycella*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina metallina Dana.
S. scarlata Giesbr.
S. nigromaculata Claus.
S. ovatolanceolata Dana—*gemma* Dana.
Ectinosoma melaniceps Boeck (= *australe* Sars, *antarcticum* Giesbr.).
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).
Clytemnestra rostrata (Brady).

In addition to the above species, that appear to have been swept by admixture of the water masses from the sub-tropical zone of one or all of the three great oceans into the West Wind Drift, certain other species appear to have been evolved in this current system ; such species are—

Clausocalanus laticeps Farran,
C. paululus Farran,
Drepanopus forcipatus Giesbr.,
D. pectinatus Brady,
Centropages auklandicus Krämer (= *discaudatus* Brady),
Acartia (*Odontacartia*) *lilljeborgi* Giesbr.,
Temora kerguelensis Brady,
Copilia hendorffi Dahl,

and perhaps to these should be added *Candacia cheirura* Cleve,* which was first recorded by Cleve (1905, p. 186) from the west of South Africa in 250–450 m., and has since been taken by the " Terra Nova " to the south of New Zealand between the Auckland and Campbell Islands (*vide* Farran, 1929, p. 273), and *Scolecithricella neptuni* Cleve, which was taken with the former species off South Africa in 250–350 m.

* Cleve, 1905, has given two different spellings for the specific name of this species ; in his Table III on p. 182 and in the alphabetical list of species on p. 186 he spells it "*chirura*," but in his account of the species on p. 198 he gives the name as "*cheirura*," and this latter spelling is followed in the alphabetical index on p. 262.

It must not be overlooked that the West Wind Drift may have contributed certain species to the fauna of the South Atlantic, and especially to the south-east area. I have already (*vide supra*, p. 403) called attention to the fact that some 23 species that are known to be present in both the south-west and south-east regions of the Pacific Ocean, but are not known from the north-east area, may have been carried eastward across the South Pacific Ocean, and it is possible that they may have been swept in the West Wind Drift still further eastward, and have reached the region to the south-west of the Cape of Good Hope and have been caught up in the Benguela Current and so carried up the west coast of Africa. Such species are—

Drepanopus forcipatus Giesbr.
Centropages brachiatus (Dana).
Acartia denticornis Brady.

Drepanopus forcipatus Giesbr. has been taken off the west coast of South America, and Brady has also recorded it from off Cape Howe, Australia, and from the tropical region of West Africa in lat. 5° 28′ N., long. 14° 38′ W., off Sierra Leone, to which position it may have been carried by the Benguela Current. *Centropages brachiatus* (Dana), also known from the west coast of South America, has been recorded from off the Cape of Good Hope (Cleve, 1905) and in the Gulf of Guinea (T. Scott, 1894).

From the West Wind Drift a few of the most resistant species appear to have been able to survive transference across the Antarctic Convergence Zone into the South Polar region. The work of Giesbrecht (1902), Brady (1910), Wolfenden (1911), T. Scott (1912), Farran (1929), Mackintosh (1934), Hardy and Gunther (1935) and Wilson (1938) has demonstrated the presence of the following species in this southern area:

Nannocalanus minor (Claus).
Paracalanus parvus (Claus).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
C. laticeps Farran.
Ctenocalanus vanus Giesbr.
Microcalanus pygmæus Sars.
Scolecithricella minor (Brady).
Drepanopus pectinatus Brady.
Labidocera acutifrons (Dana).
Oithona similis Claus.
Oncœa conifera Giesbr.
O. curvata Giesbr.
O. media Giesbr.
O. notopus Giesbr.
Conea rapax Giesbr.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*Urocorycæus*) *furcifer* Claus.
Sapphirina metallina Dana.
Ectinosoma melaniceps Boeck (= *antarcticum* Giesbr.).
Microsetalla norvegica (Boeck).
Macrosetella gracilis (Dana).

Some, and probably the majority, of these species may have been carried directly from the West Wind Drift into the Polar region by surface eddies, and this would seem to be most probable for such forms as *Clausocalanus laticeps* Farran and *Drepanopus pectinatus* Brady, which appear to have had their origin in the West Wind Drift. It is, however, possible that certain other species may have been swept southward in the deep Intermediate Currents, either in the Atlantic or the Indian Oceans, and so have reached the Sub-Antarctic region, where they have again been carried upwards to the surface. Hardy and Gunther (1935, p. 356) have suggested that such species as *Ctenocalanus vanus* Giesbr. and *Scolecithricella minor* (Brady) may by vertical migration pass from one current system to another, so that they, after being swept northwards by the Polar Current " to the limit of the Antarctic Zone, may descend . . . and make use of the great oceanic current system to return into the Antarctic Zone again in the intermediate layer flowing back towards the Pole." *Ctenocalanus vanus* Giesbr. and *Microcalanus pygmæus* Sars have almost certainly been swept by the North Atlantic intermediate current from the Atlantic Ocean to the Antarctic region; and it seems possible that several other species have traversed this route; *Nannocalanus minor* (Claus) was taken only once in the Antarctic region (*vide* Hardy and Gunther, 1935, p. 123) at a depth of 750–500 m., *Clausocalanus furcatus* (Brady) occurred in the Sub-Antarctic Zone between 1000 and 50 m., and Wolfenden (1911, pp. 366–369) has stated that *Oncœa conifera* Giesbr., *Sapphirina metallina* Dana, *Corycœus speciosus* Dana, *Oithona similis* Claus and *Labidocera acutifrons* (Dana) were captured in the South Polar region by the " Gauss " in depths of 1200–3000 m. along with numerous inhabitants of the North Atlantic Intermediate Current. Possibly *Candacia cheirura* Cleve has followed the same course; one of the two species of *Candacia* taken by the " Discovery " in the South Atlantic and recorded, but not identified, by A. Scott, in depths ranging from 100–0 m. (*vide* Hardy and Gunther, 1935) may be this species; the other species belonging to this genus is stated to be a new and unknown one.

On the north side of the Atlantic South Equatorial Current runs the Contra-equatorial Current, which passes from west to east into the Gulf of Guinea. Here also the bulk of the species of planktonic Copepoda that have been recorded appear to have been derived from the Indo-Pacific region. Thanks to the work of Brady (1883), T. Scott (1894), Cleve (1900), Wolfenden (1911), Pesta (1916), Steuer (1923) and Klevenhusen (1933) I have been able to compile the following list of species from this region:

Nannocalanus minor (Claus).
Undinula vulgaris (Dana).
Eucalanus mucronatus Giesbr.
E. setiger Brady,
Rhincalanus cornutus Dana, f. *atlantica* Schmaus.
Mecynocera clausi Thompson.
Paracalanus crassirostris F. Dahl, f. *scotti* Früch t.
P. parvus (Claus).
Calocalanus pavo (Dana).
C. plumulosus (Claus).
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Drepanopus forcipatus Giesbr.

Euchæta acuta Giesbr.
E. hebes Giesbr.
E. marina (Prestand.).
Scolecithrix danæ (Lubb.).
S. scotti Giesbr.
Scolecithricella bradyi (Giesbr.).
S. minor (Brady).
Lophothrix latipes (T. Scott).
Centropages brachiatus (Dana).
C. furcatus (Dana).
C. violaceus (Claus).
Temora longicornis (O. F. Müller).
T. stylifera (Dana).
Temoropia mayumbæensis (T. Scott).
Pseudodiaptomus serricaudatus (T. Scott).
P. hessei (Mrazek).
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bispinosa Claus.
C. curta Dana.
C. longimana Claus.
C. pachydactyla Dana.
C. pectinata Brady.
C. truncata Dana.
C. varicans Giesbr.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. detruncata (Dana).
L. nerii (Kröyer).
L. scotti Giesbr. (= *darwini* T. Scott, *non* Lubb.).
Pontella gaboonensis T. Scott.
P. inermis Brady.
P. securifer Brady.
Pontellopsis villosa Brady.
Pontellina plumata Dana.
Acartia (*Acartiura*) *clausi* Giesbr. var. *gaboonensis* T. Scott.
A. (*Acanthacartia*) *bifilosa* (Giesbr.).
A. (*A.*) *plumosa* T. Scott.
A. (*Planktacartia*) *danæ* Giesbr.
A. (*P.*) *negligens* Dana.
A. laxa Brady.
A. denticornis Brady.
Paracartia africana Steuer.
P. dubia T. Scott (= *spinicaudata* T. Scott).
Oithona atlantica Farran.
O. fallax Farran.

O. *hamata* Rosendorn.
~~O. *mediterranea* Claus.~~
O. *minuta* T. Scott.
~~O. *notopus* Giesbr.~~
O. *plumifera* Baird.
O. *pseudofrigida* Rosendorn.
O. *robusta* Giesbr.
O. *setigera* (Dana).
O. *tenuis* Rosendorn.
~~O. *venusta* Philippi.~~

Oncaea mediterranea (Claus).
O. notopus Giesbr.
O. venusta Philippi.

Concæa rapax Giesbr. (= *Oncæa gracilis* Dana).
Lubbockia squillimana Claus.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*Urocorycæus*) *furcifer* Claus.
C. (*Ditrichocorycæus*) *amazonicus* F. Dahl.
C. (*D.*) *africanus* F. Dahl.
C. (*D.*) *minimus* F. Dahl, f. *minimus*.
C. (*D.*) *minimus* var. *uncinatus* Klevenhusen.
C. (*Onychocorycæus*) *giesbrechti* F. Dahl.
C. (*O.*) *latus* Dana.
C. (*O.*) *obtusus* Dana.
C. (*O.*) *ovalis* Claus.
C. (*Corycella*) *gibbulus* Giesbr.
C. (*C.*) *gracilis* Dana.
Sapphirina auronitens Claus—*sinuicauda* Brady.
S. *inæqualis* Brady.
S. *metallina* Dana.
S. *opalina* Dana—*darwini* Haeckel.
S. *serrata* Brady.
Copilia lata Giesbr.
C. *mediterranea* (Claus).
C. *mirabilis* Dana.
C. *quadrata* Dana.
C. *vitrea* (Haeckel) (as *fultoni* T. Scott).
Pontæciella abyssicola (T. Scott).
Microsetella norvegica (Boeck).
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).
M. *oculata* Sars.
Clytemnestra scutellata Dana.
Ægisthus mucronatus Giesbr. (as *longirostris* T. Scott).

Of these 101 species, 86, or 85 per cent., have been recorded from the Indo-Pacific region. A few "species" are of doubtful authenticity, such as *Pontella inermis* Brady,

CORRIGENDA

Page 458. Genus *Oithona*. Delete :

O. mediterranea Claus.
O. notopus Giesbr.
O. venusta Philippi.

After *O. tenuis* Rosendorn. insert :

Oncaea mediterranea (Claus).
O. notopus Giesbr.
O. venusta Philippi.

Acartia laxa Brady, and *A. denticornis* Brady. Several species appear to have made their appearance in this region, either in the Gulf of Guinea or on the West African Coast, such as:

Scolecithrix scotti Giesbr.
Pseudodiaptomus hessei (Mrazek).
Labidocera scotti Giesbr.
Pontella gaboonensis T. Scott.
Paracartia africana Steuer.
P. dubia T. Scott.

A few other species are Atlantic in their origin and appear to have been swept eastwards into the Gulf of Guinea by the Contra-equatorial Current: this would account for the presence of *Acartia bifilosa* (Giesbr.) and *Labidocera nerii* (Kröyer), while *Corycæus amazonicus* F. Dahl has almost certainly been carried eastward in a similar way.

Turning now to the tropical and temperate regions that lie to the north of the Equator and the Guinea Current, we have in this area another great circular turning movement of the surface water; commencing with the North Equatorial Current the water masses pass westward across the Atlantic, part is carried into the Caribbean Sea and the Gulf of Mexico and part sweeps towards the north-west outside the Antillean arc: the former leaves the Gulf of Mexico through the Florida Strait, and beyond this is again joined by the latter to form the Gulf Stream. This is continued as the North Atlantic Drift across the ocean towards the European coast and on the east side of the Atlantic divides into two streams, part going to the north of Scotland and on to Norway or, turning left-handed towards Iceland, forms the Irminger Current, and part turning southward off the coast of Portugal and then south-west, parallel to the coast of Morocco and French West Africa, to form the Canary Current (*vide* Chart I). This great clockwise movement encloses the Sargasso Sea, and the whole system corresponds to several of Steuer's zoo-geographical regions (*vide* Steuer, 1933, p. 293); thus the Gulf Stream and the North Atlantic Drift correspond to his Sub-Arctic Atlantic sub-region, while the Canary Current and the Sargasso Sea correspond to his Northern sub-tropical Atlantic sub-region. From this current system I have been able to compile records of the following 134 species, all of which are known from the Indo-Pacific region:

Nannocalanus minor (Claus).
Undinula darwini Lubb.
U. vulgaris (Lubb.).
Eucalanus crassus Giesbr.
E. monachus Giesbr.
E. mucronatus Giesbr.
E. subtenuis Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. parvus (Claus).
Acrocalanus longicornis Giesbr.
Calocalanus contractus Farran.

C. pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
C. pergens Farran.
Pseudocalanus minutus Kröyer.
Euchæta acuta Giesbr.
E. hebes Giesbr.
E. marina (Prestand.).
E. media Giesbr.
E. philippi Brady.
E. pubera Sars.
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).
S. dentata Giesbr.
S. minor (Brady).
Centropages brachiatus (Dana).
C. bradyi Wheeler.
C. furcatus (Dana).
C. gracilis (Dana).
C. kröyeri Giesbr.
C. violaceus Brady.
Temora longicornis Baird.
T. stylifera (Dana).
T. turbinata (Dana).
Lucicutia flavicornis (Claus).
Candacia æthiopica Dana.
C. bipinnata Giesbr.
C. bispinosa Claus.
C. curta Dana.
C. inermis Cleve (= *obtusa* Sars).
C. longimana Claus.
C. pachydactyla Dana.
C. pectinata Brady.
C. simplex Giesbr.
C. tenuimana Giesbr.
C. truncata Dana.
C. varicans Giesbr.
Labidocera acuta (Dana).
L. acutifrons (Dana).
L. kröyeri (Brady).
L. wollastoni (Lubb.).
Pontella securifer Brady.
P. spinipes Giesbr.
Pontellopsis perspicax (Dana).

P. regalis (Dana).
P. villosa Brady.
Pontellina plumata Dana.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Acanthacartia*) *tonsa* Dana.
A. (*Odontacartia*) *centrura* Giesbr.
A. (*Planktacartia*) *danæ* Giesbr.
A. (*P.*) *negligens* Dana.
Oithona atlantica Farran.
O. brevicornis Giesbr.
O. nana Giesbr.
O. plumifera Baird.
O. pseudofrigida Rosendorn.
O. robusta Giesbr.
O. setigera Dana.
O. similis Claus.
O. simplex Farran.
O. tenuis Rosendorn.
O. vivida Farran.
Paroithona parvula Farran.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
O. subtilis Giesbr.
O. notopus Giesbr.
O. venusta Philippi.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
? *Corycæus* (*Corycæus*) *crassiusculus* (? = *clausi* F. Dahl).
C. (*C.*) *speciosus* Dana.
C. (*Monocorycæus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *lautus* Dana.
C. (*U.*) *furcifer* Claus.
C. (*Ditrichocorycæus*) *minimus* F. Dahl.
C. (*Onychocorycæus*) *catus* F. Dahl.
C. (*O.*) *giesbrechti* F. Dahl.
C. (*O.*) *latus* Dana.
C. (*O.*) *obtusus* (? = *ovalis* Claus).
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.

S. auronitens Claus—*sinuicauda* Brady.
S. bicuspidata Giesbr.
S. gastrica Giesbr.
S. intestinata Giesbr.
S. iris Dana.
S. lactens Giesbr.
S. metallina Dana.
S. nigromaculata Claus.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
S. stellata Giesbr.
Copilia lata Giesbr.
C. mediterranea (Claus).
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea (Haeckel).
Ectinosoma melaniceps Boeck.
E. normani T. and A. Scott.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).
M. oculata Sars.
Miracia efferata Dana.
Clytemnestra rostrata (Brady).
C. scutellata Dana.
Ægisthus aculeatus Giesbr.
Æ. mucronatus Giesbr.

A comparison of the species in the above list with those that have been taken in the Southern Hemisphere in the counter-clockwise system of the South Atlantic reveals that a relatively few Indo-Pacific species have been reported from the North Atlantic, but have not as yet been taken in the south; these species are as follows:

Calocalanus styliremis Giesbr.
Euchæta media Giesbr.
Centropages bradyi Wheeler.
C. kröyeri Giesbr.
Candacia tenuimana Giesbr.
Oncæa minuta Giesbr.
Lubbockia aculeata Giesbr.
Sapphirina bicuspidata Giesbr.
Macrosetella oculata Sars.

It seems probable that further research will reveal their presence in the more southerly area. On the other hand, there are a number of Indo-Pacific species that have been taken

in the South Atlantic, but have not, so far, been recorded from the North Atlantic ; these species are as follows :

Canthocalanus pauper (Giesbr.).
Eucalanus pileatus Giesbr.
Paracalanus crassirostris F. Dahl.
Euchæta concinna Dana.
Centropages calaninus Dana.
Pseudodiaptomus serricaudatus (T. Scott).
Labidocera detruncata (Dana).
Pontella fera Dana.
Acartia (*Acanthacartia*) *plumosa* T. Scott.
Oithona attenuata Farran.
O. fallax Farran.
O. hamata Rosendorn.
Corycæus (*Onychocorycæus*) *agilis* Dana.
Sapphirina maculosa Giesbr.

While some of these may be found by further research in the North Atlantic, it seems more probable, in view of the great amount of work that has already been carried out in this region, that these species have been able to get round the Cape of Good Hope into the southern area, but have not as yet been able to extend their habitat into the northern region.

In the water of the Gulf Stream the following Indo-Pacific species have been recorded (*vide* Wheeler, 1901, and Wilson, 1932 and 1942).

Nannocalanus minor (Claus).
Undinula vulgaris (Lubb.).
Eucalanus monachus Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
Calocalanus pavo (Dana).
C. plumulosus (Claus).
Clausocalanus arcuicornis (Dana).
Euchæta marina (Prestand.).
Scolecithrix danæ (Lubb.).
Centropages bradyi Wheeler.
C. furcatus (Dana).
Temora longicornis Baird.
T. stylifera (Dana).
Candacia armata Boeck (= *pectinata* Brady).
C. pachydactyla Dana.
Labidocera acutifrons (Dana).
Pontella securifer Brady.
Pontellopsis regalis (Dana).
Pontellina plumata Dana.

Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Acanthacartia*) *tonsa* Dana.
A. (*Planktacartia*) *danæ* Giesbr.
Oithona atlantica Farran (as *spinirostris* Claus).
O. brevicornis Giesbr.
O. plumifera Baird.
O. similis Claus.
Oncæa minuta Giesbr.
O. venusta Philippi.
? *Corycæus* (*Corycæus*) *crassiusculus* Dana (? = *clausi* F. Dahl).
C. (*C.*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *latus* Dana.
C. (*Ditrichocorycæus*) *minimus* F. Dahl.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *gibbulus* Giesbr.
C. (*C.*) *gracilis* Dana.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. nigromaculata Claus.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
Copilia denticulata Claus (= *mediterranea* Claus).
Ectinosoma normani T. and A. Scott.
Microsetella norvegica (Boeck).
M. rosea Dana.
Macrosetella gracilis (Dana).
M. oculata Sars.
Miracia efferata Dana.
Clytemnestra rostrata (Brady).
C. scutellata Dana.

And to these should be added the following species that, although not actually recorded from the Gulf Stream itself, have been taken in the near neighbourhood :

Eucalanus crassus Giesbr.
Scolecithricella minor (Brady).
Temora turbinata (Dana).
Lucicutia flavicornis (Claus).
Oithona nana Giesbr.
Oncæa conifera Giesbr.

We thus have as many as 59 Indo-Pacific species in the Gulf Stream off the coast of North America.

Species that inhabit the warm water of the Gulf Stream will be swept northwards and eastwards into the North Atlantic Drift and on towards the coasts of Europe, and will

become part of the fauna of Steuer's Sub-Arctic Atlantic Sub-region. The actual distance to which such species may be carried and still survive will depend on their degree of resistance to cooling, and Rose (1920) has, under the heading "Distribution," noted that several of the above species appear to be present only in the western part of the North Atlantic, namely, to the west and south of the Azores and near the American coast; these species are—

Undinula vulgaris (Lubb.).
Centropages gracilis (Dana).
Candacia pachydactyla Dana.
Pontella securifer Brady.
Miracia efferata Dana.

Sapphirina auronitens-sinuicauda, *Corycæus lautus* and *Corycella gracilis* reach the Canary Islands and the coast of French West Africa, and *Candacia longimana* appears to have reached the Gulf of Gascony, but is not found further to the north. Other species of the genus *Sapphirina* also appear to die out in the North Atlantic; *Sapphirina gastrica* Giesbr. has been recorded from the coast of Mauretania in West Africa, and *S. bicuspidata* Giesbr., *S. intestinata* Giesbr., *S. maculosa* Giesbr., *S. lactens* Giesbr., *S. metallina* Dana and *S. scarlata* Giesbr. have all got into the Mediterranean Sea, though they have never been recorded to the north of lat. 40° N.

Within the tropical and temperate regions of the North Atlantic Ocean a number of species appear to have had their origin, namely:

Calocalanus tenuis Farran.
Scolecithricella ovata Farran.
Diaixis pygmæa T. Scott.
Pseudodiaptomus americanus Wright.
P. coronatus Wilson.
P. cristobalensis Marsh.
P. pelagicus Herrick.
Lucicutia gemina Farran.
Pseudocyclops magnus Esterly.
Lampoidopus marki Esterly.
Anomalocera patersoni Templ.
Pontella atlantica (M. E.).
P. lobiancoi Canu.
P. mediterranea Claus.
Parapontella brevicornis Lubb.
Acartia (*Acartiura*) *bermudensis* Esterly.
A. (*Euacartia*) *macropus* Cleve.
A. (*Acanthacartia*) *spinata* Esterly.
Corycæus (*Ditrichocorycæus*) *anglicus* Lubb.
C. (*Onychocorycæus*) *latus* Dana.
Halithalestris croni Kröyer.
Ægisthus atlanticus Wolfenden.

Æ. dubius Sars.*
Oncœa anglica Brady.
O. similis Sars.
O. tenella Sars.

And to these we should perhaps add—

Centropages chierchiæ Giesbr.
C. hamatus (Lillj.).
C. typicus Kröyer.

I have already called attention (*vide supra*, pp. 400, 410) to the fact that several species of Copepods that are known to inhabit the North Atlantic, and especially the Sub-Arctic region, have been recorded from the North Pacific Ocean, namely :

Centropages hamatus (Lillj.).
Temora longicornis (Müll.).
Anomalocera patersoni Templ.
Pontella atlantica (M. E.).
Acartia longiremis (Lillj.).
? A. bifilosa Giesbr. (as *A. clausi* Giesbr.).
Oncœa anglica Brady.
O. similis Sars.
O. tenella Sars.

None of these species is truly Arctic in its habitat, and it is possible that further researches may reveal that they are widely distributed, though of rare occurrence, in warmer waters ; but, if their distribution is so restricted and so discontinuous as appears to be the case at present, there must have been a connecting channel, in which conditions of temperature were suitable for their survival and reproduction, and by which they could be carried from one region to the other, but which has since, either by orographical or meteorological changes, been rendered impassable. One such channel in the tropical region was in existence in early Tertiary times between the Atlantic and Pacific Oceans across Central America, but since these species to-day are not tropical species, but rather temperate and cool water forms, it seems more probable that the connecting channel must be sought in the Arctic region. Berg (1934) has put forward the view that such a discontinuity can be accounted for by the climatic changes that were brought about at the close of the last glacial period ; at that time the northern climate became warmer, and during this warm post-glacial period species may have been able to extend their distribution along the north Asiatic coast and so pass through the Bering Strait, which was then open, into the North Pacific area. Berg quotes as examples of such distribution a number of Molluscs, among which are several Lamellibranchs, such as *Mytilus edulis* and *Modiola modiolus*, which must have carried out any extension of their habitat during their planktonic larval stage, and it seems probable that other planktonic organisms, such as the Copepoda, may have been carried from one ocean to the other during this warm period.

* There is a possibility that this species, which is at present only known from the male, may be a synonym of *Ægisthus mucronatus* Giesbr. Sars has rejected this view, but Farran considers that the question is still open.

Ekman (1935, p. 239) agrees with Berg's view, though he points out that in those cases in which the actual species in the two oceans are not identical, though very closely related, the migration from one region to the other must have taken place at a more remote period, probably during the Tertiary epoch.

As the Gulf Stream and its continuation, the North Atlantic Drift, sweeps eastward across the North Atlantic Ocean the current divides into two main streams, one of which passes eastward towards the Bay of Biscay and the coast of Portugal, while the other passes towards the north-east to reach the channel between Iceland and Scotland (*vide* Chart I). Planktonic species that are carried eastward in the former branch may either reach the coast of Portugal, whence they will be swept southwards in the Canary Current past the entrance to the Mediterranean Sea, and by the inflowing surface current may be carried into that region, or else they may be swept into the Bay of Biscay or more to the north and so reach the coasts of the British Isles. Candeias (1929) has recorded the following species from the coast of Portugal:

**Nannocalanus minor* (Claus).
**Calanoides brevicornis* (Lubb.).
Eucalanus atlanticus Candeias.
**E. crassus* Giesbr.
**Paracalanus parvus* (Claus).
Pseudocalanus elongatus (Boeck).
**Clausocalanus arcuicornis* (Dana).
**Euchæta hebes* Giesbr.
**E. media* Giesbr.
**E. pubera* Sars.
**Scolecithrix danæ* (Lubb.).
**Scolecithricella bradyi* (Giesbr.).
**S. dentata* Giesbr.
**Temora longicornis* Baird.
**T. stylifera* (Dana).
**Centropages bradyi* Wheeler.
C. chierchiæ Giesbr.
**C. kröyeri* Giesbr.
**C. violaceus* Brady.
**Lucicutia flavicornis* (Claus.)
**Candacia armata* Boeck (= *pectinata* Brady).
**C. bipinnata* Giesbr.
Anomalocera patersoni Templ.
Labidocera wollastoni (Lubb.).
**Pontellopsis villosa* Brady.
**Acartia (Acartiura) clausi* Giesbr.
**A. (Planktacartia) danæ* Giesbr.
**Oithona similis* Claus.
**O. plumifera* Baird.
**Oncæa conifera* Giesbr.
**O. media* Giesbr.

**O. mediterranea* Claus.
**O. venusta* Philippi.
**Lubbockia aculeata* Giesbr.
**Corycæus (Agetes) flaccus* Giesbr.
**C. (Urocorycæus) lautus* Dana.
C. (Onychocorycæus) ovalis Claus.
**Sapphirina angusta* Dana.
S. escartiata Candeias.
**S. ovatolanceolata* Dana—*gemma* Dana.
**S. scarlata* Giesbr.
**Microsetalla rosea* Dana.

Of these 42 species as many as 35, marked with an asterisk, or 83 per cent., are Indo-Pacific forms.

A more northerly branch of the North Atlantic Drift sweeps eastward into the Bay of Biscay, and, thanks to Farran (1926), we have records of the following 33 Indo-Pacific epiplanktonic species from that area:

Nannocalanus minor (Claus).
Eucalanus crassus Giesbr.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
Calocalanus contractus Farran.
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. paululus Farran.
C. pergens Farran.
Euchæta acuta Giesbr.
Scolecithricella dentata Giesbr.
Lucicutia flavicornis (Claus).
Candacia armata Boeck.
C. obtusa Sara (= *inermis* Cleve, *rotundata* Wolf.).
C. tenuimana Giesbr.
Acartia (Acartiura) clausi Giesbr.
Oithona atalantica Farran.
O. setigera Dana.
O. similis Claus.
Oncæa conifera Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. subtilis Giesbr.
Conæa rapax Giesbr.
Lubbockia aculeata Giesbr.
Corycæus (Urocorycæus) furcifer Claus.
Sapphirina nigromaculata Claus.
Vettoria granulosa (Giesbr.).
Microsetella norvegica (Boeck).

M. rosea Dana.
Clytemnestra rostrata (Brady).
C. scutellata Dana.
Ægisthus aculeatus Giesbr.
Æ. mucronatus Giesbr.
Pontœciella abyssicola (T. Scott).

From this and the preceding list together we have records of 52 Indo-Pacific species from the west coast of Europe.

I have been able to collate records of 120 epiplanktonic species that occur in the Mediterranean Sea (*vide* Giesbrecht (1892), Sars (1907), Steuer (1910), Früchtl (1920), Pesta (1920) and Rose (1934). (Pesta gives a number of references to other papers that deal with this region.) Of these species the following are known from the Indo-Pacific region :

Nannocalanus minor (Claus).
Eucalanus crassus Giesbr.
E. monachus Giesbr.
Mecynocera clausi Thompson.
Paracalanus aculeatus Giesbr.
P. nanus Sars.
P. parvus (Claus).
? *P. pygmæus*. (Claus).
Calocalanus pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
Ctenocalanus vanus Giesbr.
Euchæta acuta Giesbr.
E. hebes Giesbr.
E. marina (Prestand.).
E. media Giesbr.
Scolecithrix danæ (Lubb.).
Scolecithricella bradyi (Giesbr.).
S. dentata (Giesbr.).
S. ovata Farran.
S. tenuiserrata (Giesbr.).
Centropages auklandicus Krämer.
C. bradyi Wheeler.
C. kröyeri Giesbr.
C. violaceus Brady.
Temora longicornis Baird.
T. stylifera (Dana).
Lucicutia flavicornis (Claus).
Pseudocyclops umbraticus Giesbr.
Candacia æthiopica Dana.
C. bipinnata Giesbr.

C. bispinosa Claus.
C. longimana Claus.
C. pectinata Brady (= *armata* Boeck).
C. simplex Giesbr.
C. tenuimana Giesbr.
C. varicans Giesbr.
Labidocera acutifrons (Dana).
L. kröyeri (Brady).
L. wollastoni (Lubb.).
Pontellopsis regalis (Dana).
P. villosa Brady.
Pontellina plumata Dana.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Planktacartia*) *danæ* Giesbr.
A. (*P.*) *negligens* Dana.
Oithona brevicornis Giesbr.
O. atlantica Farran.
O. linearis Giesbr. (? = *setigera* Dana).
O. nana Giesbr.
O. plumifera Baird.
O. robusta Giesbr.
O. setigera Dana.
O. similis Claus.
Oncæa conifera Giesbr.
O. dentipes Giesbr.
O. media Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
O. subtilis Giesbr.
O. venusta Philippi.
Lubbockia squillimana Claus.
Pontœciella abyssicola (T. Scott).
Corycæus (*Corycæus*) *clausi* F. Dahl.
C. (*C.*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*A.*) *limbatus* Brady.
C. (*A.*) *typicus* Kröyer.
C. (*Urocorycæus*) *furcifer* Claus.
C. (*U.*) *lautus* Dana.
C. (*Onychocorycæus*) *catus* F. Dahl.
C. (*O.*) *giesbrechti* F. Dahl.
C. (*O.*) *latus* Dana.
C. (*O.*) *obtusus* Dana.
C. (*O.*) *ovalis* Claus
? *C.* (*Corycella*) *carinatus* Giesbr

C. (*C.*) *curtus* Farran.
C. (*C.*) *rostratus* Claus.
Corina granulosa Giesbr. (= *Vettoria g.* (Giesbr.)).
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. bicuspidata Giesbr.
S. lactens Giesbr.
S. maculosa Giesbr.
S. metallina Dana.
S. nigromaculata Claus.
S. iris Dana.
S. opalina Dana—*darwini* Haeckel.
S. ovatolanceolata Dana—*gemma* Dana.
? *S. scarlata* Giesbr.
? *S. stellata* Giesbr.
Copilia mediterranea (Claus).
C. mirabilis Dana.
C. quadrata Dana.
C. vitrea (Haeckel).
Ectinosoma melaniceps Boeck.
Microsetella norvegica (Boeck).
M. rosea Dana.
Euterpina acutifrons (Dana).
Macrosetella gracilis (Dana).
Clytemnestra scutellata Dana.
C. rostrata (Brady).

The occurrence of four of the above species in the Mediterranean Sea appears to be open to doubt, but in this area no less than 103 Indo-Pacific species, constituting about 86 per cent. of the planktonic population, are known to be present. In addition to these Indo-Pacific species some 12 or 14 other species, that appear to have had their origin in the Atlantic Ocean, have also been recorded, namely :

Calanus finmarchicus Gunn.
? *Centropages chierchiæ* Giesbr.
C. hamatus (Lillj.).
C. typicus Kröyer.
Isias clavipes Boeck.
Diaixis pygmæa T. Scott.
Pontella atlantica (M. E.).
P. lobiancoi Canu.
P. mediterranea Claus.
Anomalocera patersoni Templ.
Parapontella brevicornis (Lubb.).
? *Paracartia dubia* (T. Scott).
Corycæus (*Ditrichocorycæus*) *anglicus* Lubb.
Oncæa tenella Sars.

A few other species that have been recorded from the Mediterranean Sea are well known boreal or Arctic forms, namely :

Ctenocalanus vanus Giesbr.,
Pseudocalanus elongatus (Boeck),
Xanthocalanus minor Giesbr.,
Cyclopina elegans T. Scott,
C. longicornis Boeck,
Ectinosoma neglectum Sars,

and it has been claimed that some, at least, of these represent a " relict " fauna from the last Glacial period. Pesta (1920, p. 484) and Rose (1920) both dissent from this view, and Rose has suggested that *Pseudocalanus elongatus* (Boeck) and, in all probability, *Temora longicornis* Baird are carried into the Mediterranean Sea by the current that flows through the Strait of Gibraltar ; the claim that *Temora longicornis* is a boreal or Arctic species overlooks the fact that this species has been recorded from the south-west Pacific Ocean, the Indian Ocean and the tropical region of the Atlantic Ocean. The two species of *Cyclopina* are known from the British Isles and the coast of Norway, and *C. longicornis* Boeck occurs also in Arctic waters.

Several species, some ten in number, appear to have had their origin in the Mediterranean Sea or its offshoot the Black Sea, namely :

Euchæta trunculosa Pesta (? a young stage),
Centropages ponticus Karawiew,
Labidocera brunescens (Czern.),
Stephus gyrans Giesbr.,
Acartia (*Hypoacartia*) *adriatica* Steuer,
A. (*Acanthacartia*) *italica* Steuer,
A. (*Paracartia*) *latisetosa* (Kriczagin),
Corycæus (*Ditrichocorycæus*) *brehmi* Steuer,
Ratania flava Giesbr.,
Cyclopina esilis Brian,

and to these should, perhaps, be added *Centropages chierchiæ* Giesbr., which Farran has suggested is a Mediterranean species. Ekman (1935, p. 423) has called attention to the difference that is to be found in the fauna of the eastern and western basins of the Mediterranean Sea, the latter being in general richer than the former ; as a possible cause of this he notes that the eastern, and especially the south-eastern region of the Mediterranean is warmer and has a higher salinity than the western area.*

Schott (1928) has reviewed our knowledge of the currents from the Atlantic Ocean into the Mediterranean Sea through the Strait of Gibraltar, and he shows that there is, at almost all times, an inflowing current from the Atlantic Ocean, which is, owing to the effect of the earth's rotation, stronger on the African side than on the European ; he also notes that the strength of the current will vary with the wind, a strong west wind causing an increase in the current, while a strong east wind may succeed in stopping it altogether. Most of the Indo-Pacific species that have been found in the Mediterranean Sea, and those that had their origin in the Atlantic Ocean, can have been swept into the Mediterranean

* He also calls attention to the work of Thomsen (1931), who showed that the Mediterranean Sea as a whole, and the eastern region in particular, is markedly deficient in nitrates and phosphates.

Sea by this current from the Atlantic ; indeed it seems possible, or even probable, that this transference is still going on, for Rose (1929) has pointed out that at the present time several species appear to be mainly confined to the western area and are but rarely taken in the eastern region. Such species are—

Calocalanus styliremis Giesbr.
Centropages violaceus Brady.
Isias clavipes Boeck.
Pseudocalanus elongatus (Boeck).
Temora longicornis Baird.
Candacia æthiopica Dana.
C. varicans Giesbr.
Labidocera kröyeri (Brady).
Parapontella brevicornis (Lubb.).
Pontellopsis regalis (Dana).
Acartia (*Planktacartia*) *danæ* Giesbr.

It seems probable that these have been swept in through the Strait of Gibraltar, but have not as yet permanently established themselves in the eastern part of the Mediterranean.

In a few instances the known distribution is markedly discontinuous ; *Centropages auklandicus* Krämer is at present known only from the south-west Pacific and the Mediterranean regions. *Oithona hebes* Giesbr. has been recorded from the Caribbean Sea, the East Pacific area and the Mediterranean Sea ; *Oncæa dentipes* Giesbr. has been taken in both east and south-west Pacific areas and in the Mediterranean Sea ; and finally *Centropages kröyeri* Giesbr., *Candacia tenuimana* Giesbr., *Vettoria granulosa* (Giesbr.) and *Pontœciella abyssicola* (T. Scott) are known from the Indo-Pacific region, the Mediterranean Sea and the Atlantic in the Gulf of Guinea. It is possible that all these may be " relict " species that originally attained their present distribution through the Tethys Sea in early Tertiary times, but this view takes no cognizance of the possible changes that occurred in the Mediterranean region during the last Glacial period.

The geological history of this region has been summarized by Munro Fox (1929, p. 844) as follows : " In Tertiary times the present Red Sea was a branch of the Mediterranean, unconnected with the Indian Ocean. Later, a southern water connection was effected, and the Red Sea then harboured a mixed Mediterranean and Indian Ocean fauna. Next the Red Sea became cut off from the Mediterranean by the Isthmus of Suez. This is composed of Quaternary deposits, containing the remains of marine faunas to the north and south and of a fresh-water fauna in the centre." Fuchs (1881) and Keller (1882) have both reviewed our knowledge of the conditions that existed in this area at the beginning of the Quaternary, and they have shown that in the Pleistocene the Mediterranean Sea extended southwards over the region of the Suez Canal as far as Lake Timsah. Lake Timsah and the region round it seems to have been occupied by a fresh-water area that was connected with the Nile River, while the Red Sea extended northwards as far as the Bitter Lakes. Steinitz (1929) has, however, again reviewed our knowledge, and he has reached the conclusion that the so-called fresh-water area round Lake Timsah was in reality an estuarine region in which the surface water was fresh, but that beneath this marine conditions persisted, so that there was thus a through channel for marine organisms : and in his opinion in Quaternary times immigration from the Red Sea into the Mediter-

ranean Sea across the Suez isthmus was as great as, or even greater than, the influx from the Atlantic Ocean through the Strait of Gibraltar. None of these authors, however, takes account of the changes that in all probability took place in Pleistocene times during the last Glacial period. There is a considerable body of evidence that indicates that during the Glacial epoch there was a change in the relative levels of sea and land, partly as a result of the lowering of the sea level and partly by elevation of the land. Zeuner (1945) has recently reviewed our knowledge of the extent to which the sea-level fell during the last Glacial period as a result of the ice formation, and he shows that there was a succession of fluctuations during the period. Estimates of the amount of maximum lowering of sea-level vary from 90 to 200 m. These changes resulted in the formation of land isthmuses between Europe and Africa ; the most westerly of these was situated where the

TEXT-FIG. 87.—The Mediterranean Region during the last Glacial Period. (From H. G. Wells.)

Strait of Gibraltar now lies, and the second ran from Tunis through Malta and Sicily to Italy, while possibly a third isthmus connected Asia Minor with the Balkan Peninsula (*vide* Text fig. 87). The evidence for the existence of the Sicilian bridge is clearly given by Sir Arthur Keith (1929, p. 342 *et seq.*). If these changes actually took place, this interruption of the continuity of the Atlantic Ocean and Mediterranean Sea must have resulted in the formation of two separate lakes, entirely unconnected with either the Indo-Pacific or Atlantic region. Of the two Mediterranean lakes the eastern would have been the fresher, since it was fed by the Nile, the " Adriatic " river, and perhaps by a river that carried away the outflow from the Central Asiatic Lake that then existed. As Wells (1930) has pointed out, " When the Mediterranean was cut off from the Atlantic Ocean

and the Black Sea it must have been a shrinking sea, with its waters sinking to a much lower level than that of the ocean outside. This is the case of the Caspian Sea to-day. Still more so is it the case with the Dead Sea." Similarly, the separation of the Red Sea from both the Mediterranean Sea and the Indian Ocean by the relative elevation of the "sill" that now extends from Arabia through the Hanish Islands and Jebel Zukheir to Africa, and which now lies at a depth of only about 100 m., must have resulted in the almost complete disappearance of the Red Sea as it exists to-day and its reduction to two small inland lakes that were in all probability hypersaline. Under such changes as these it is difficult to suppose that anything of the marine fauna can possibly have survived, and the original fauna of the Tethys Sea that was derived from the Indo-Pacific region must have disappeared. At the close of the Glacial Period, when the sea-level again rose, and perhaps also the land sank, so that the Strait of Gibraltar at the one end and the Strait of Bab-el-Mendeb at the other again permitted the influx of oceanic water, a marine fauna will have been swept in from the Atlantic Ocean to the Mediterranean Sea and from the Indian Ocean to the Red Sea. Among the immigrants from the Atlantic Ocean to the Mediterranean Sea a number of Atlantic species will have been carried in, and with these will have gone some of those that formerly inhabited the whole length of the Tethys Sea and were originally Indo-Pacific in origin: but some species of this latter group may not as yet have succeeded in penetrating back again from the North Atlantic into the Mediterranean Sea and in establishing themselves as permanent inhabitants, and the interruption between the Mediterranean Sea and the Red Sea that arose during the Quaternary will have prevented their ingress from the Indian Ocean; and thus their now discontinuous distribution can well be explained.

The Post-Glacial re-population of the Mediterranean Sea must have been in the main from the Atlantic Ocean and that of the Red Sea from the Indian Ocean, and until the construction of a canal between these two areas there can have been but little opportunity for the fauna of one region to pass to the other. Pesta (1920) has given a list of eight species that he seems to think have made their way into the Mediterranean Sea direct from the Indian Ocean and the Red Sea, and he claims that these species are absent from the Atlantic Ocean. The species that he names include both surface- and deep-dwelling forms; the surface-living species are:

Eucalanus monachus Giesbr.
Candacia longimana Claus.
C. tenuimana Giesbr.
C. simplex Giesbr.
Acartia (*Planktacartia*) *negligens* Dana.
Sapphirina auronitens Claus.

Every one of these has been recorded from the North Atlantic Ocean, and neither *Eucalanus monachus* Giesbr. nor *Candacia tenuimana* Giesbr. have as yet been reported from the Red Sea. Monro Fox (1927, p. 171, Table 20) considers that five species have entered the Suez Canal from the Mediterranean Sea end, namely:

Temora stylifera (Dana).
Corycæus (*Ditrichocorycæus*) *brehmi* Steuer.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Paracartia*) *latisetosa* (Kriczagin).
Centropages ponticus Karawiew,

He also think that *Oithona nana* Giesbr., *Oncæa media* Giesbr. and *Euterpina acutifrons* (Dana) have entered the canal from both ends. *Temora stylifera* (Dana) and *Acartia clausi* Giesbr. have both been recorded from the Gulf of Suez, so that, though the evidence at Monro Fox's disposal certainly seems to suggest a northern origin, it is possible that both these species may at some time or other have penetrated northwards from the Gulf. *Oithona nana* Giesbr. certainly seems to have entered the canal from both ends, since the forms at each end are different (*vide* Gurney, 1927, p. 159), and *Paracalanus parvus* (Claus) has almost certainly done so, since here again the forms at the two ends of the canal are different, f. *indicus* having entered from the Gulf of Suez and f. *borealis* from the Mediterranean Sea. Gurney (1927, p. 141) is of the opinion that two species, namely, *Canthocalanus pauper* Giesbr. and *Temora discaudata* Giesbr., " seem to afford evidence of a northward migration " through the Suez canal from the Red Sea, and as neither of these species have as yet been recorded from either the tropical or north temperate regions of the Atlantic Ocean, it is probable that he is right. On the other hand, Gurney (*loc. cit.*, p. 161) concludes that " the genus *Corycæus* provides strong evidence that the plankton species, which are common to the Red Sea and the Mediterranean, have not crossed the isthmus (of Suez). . . . It is obvious that the *Corycæus* of the Mediterranean have come from the west and not by the Isthmus." There thus seems to be very little evidence of any large transference of planktonic species from the Red Sea into the Mediterranean Sea through the Suez Canal under present conditions ; this seems to be a direct contradiction of what I showed to be the case among the weed-haunting Harpacticoida (*vide* Sewell, 1940a, p. 268), among which as many as 15 species seem to have passed from the Red Sea to the Mediterranean. The explanation of this difference is probably to be found in the different habitats of the two groups—the weed-haunting forms can be carried passively and rapidly through the canal in the weed on ship's bottoms, while the truly planktonic forms will have to survive the changes in temperature and salinity in the canal for several days, since it will take a succession of tides to sweep them through the whole distance, and hence have not reached the Mediterranean Sea in sufficiently large numbers to have been able to establish themselves in the new locality. Even where such a transference may have been accomplished, it might be masked by the presence in the Mediterranean Sea of other individuals of the same species that have been swept in from the Atlantic Ocean through the Strait of Gibraltar.

From the Bay of Biscay a branch of the North Atlantic Drift runs northwards across the mouth of the English Channel to the west of Ireland, where it is joined by another branch of the Drift, and the combined water mass sweeps round the north of Scotland and there divides into two streams, the one passing between Scotland and the Shetland Islands and turning south again on the east side of Scotland to sweep round the North Sea, and the other passing to the north of the Shetland Islands, continuing in its north-easterly course to flow along the coast of Norway to the Barents Sea. As we follow the current northwards we find a considerable falling off in the total number of species that have been recorded from any given area, though the number of individuals present may very considerably increase. From the coasts of the British Isles and the region to the west of Ireland some species of epiplanktonic Copepoda have been recorded (*vide* Brady (1878–81), Thompson (1887, 1895, 1896, 1897), T. Scott (1897 to 1905, a series of papers in the 'Annual Report of the Fishery Board for Scotland'), Farran (1903, 1905, 1908, 1920), Norman and T. Scott (1906), Ostenfeld (1906, 1916), Pearson (1906), Gurney (1907, 1931),

Norman and Brady (1909). and Marine Biological Association (1931). Of the recorded species from this area the following 64 are Indo-Pacific species :

Eucalanus crassus Giesbr.
Rhincalanus cornutus Dana.
Mecynocera clausi Thompson.
Paracalanus parvus (Claus).
Calocalanus contractus Farran.*
C. pavo (Dana).
C. plumulosus (Claus).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
C. paululus Farran.*
C. pergens Farran.*
Euchæta acuta Giesbr.
E. hebes Giesbr.
E. marina (Prestand.).
Scolecithrix danæ Lubb.
Scolecithricella bradyi Giesbr.
S. dentata Giesbr.
S. minor (Brady).
Temora longicornis Baird.
T. stylifera (Dana).
Temoropia mayumbæensis T. Scott.
Pseudocyclops obtusatus Brady and Robertson.
Lucicutia flavicornis (Claus).
Candacia pectinata Brady.
C. rotundata Wolfend. (= *inermis* Cleve).
C. tenuimana Giesbr.
C. varicans Giesbr.
Labidocera acuta (Dana).
L. kröyeri (Brady).
L. wollastoni (Lubb.).
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*A.*) *longiremis* (Lillj.).
A. (*Odontacartia*) *centrura* Giesbr.
Oithona atlantica Farran.
O. nana Giesbr.
O. plumifera Baird.
O. setigera Dana.
O. similis Claus.
Paroithona parvula Farran.
Oncæa conifera Giesbr.
O. media Giesbr.

* This species was described by Farran (1926), from the Bay of Biscay. So far as I know, it has not yet been recorded from the Irish Coast or the British Isles.

O. mediterranea Claus.
O. minuta Giesbr.
O. notopus Giesbr.
O. ornata Giesbr.
O. subtilis Giesbr.
O. venusta Philippi.
Conœa rapax Giesbr.
Lubbockia aculeata Giesbr.
L. squillimana Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana (= *venustus* Dana).
C. (*C.*) *speciosus* Dana.
Sapphirina iris Dana (= *salpæ* Claus).
Corina granulosa Giesbr. (= *Vettoria g.*).
Ectinosoma melaniceps Boeck.
E. normani T. and A. Scott.
Microsetella norvegica (Boeck).
M. rosea Dana.
Macrosetella gracilis Dana.
Euterpina acutifrons (Dana).
Clytemnestra rostrata (Brady).
C. scutellata Dana.
Ægisthus mucronatus Giesbr.
Æ. aculeatus Giesbr.

There appear to be considerable differences in the fauna of different regions of the British coasts. The main drift of Atlantic water at the present time appears to pass across the entrance to the English Channel and sweep up the west coast of Ireland ; and, as a result, by far the greater number of Indo-Pacific species have been taken in this region. I have been able to collate references to as many as 51 different Indo-Pacific species (*vide* Brady and Robertson (1872), Brady (1878–81), Thompson (1896, 1897, 1903), Farran (1903, 1905), Pearson (1906)) :

**Eucalanus crassus* Giesbr.
**Rhincalanus cornutus* Dana.
**Mecynocera clausi* Thompson.
Paracalanus parvus (Claus).
**Calocalanus pavo* (Dana).
**C. styliremis* Giesbr.
Clausocalanus arcuicornis (Dana).
Euchæta acuta Giesbr.
E. marina (Prestand.).
**Scolecithrix danæ* Lubb.
**Scolecithricella dentata* Giesbr.
**S. bradyi* Giesbr.
**S. minor* (Brady).
Temora longicornis Baird.
T. stylifera (Dana).

**Temoropia mayumbæensis* T. Scott.
Pseudocyclops obtusatus Brady and Robertson.
**Lucicutia flavicornis* (Claus).
Candacia pectinata Brady.
**C. rotundata* Wolf.
**Labidocera kröyeri* (Brady).
L. wollastoni (Lubb.).
Acartia (*Acartiura*) *clausi* Giesbr.
**A.* (*Odontacartia*) *centrura* Giesbr.
Oithona nana Giesbr.
O. plumifera Baird.
O. similis Claus.
**Paroithona parvula* Farran.
**Oncæa conifera* Giesbr.
**O. media* Giesbr.
O. mediterranea Claus.
O. minuta Giesbr.
**O. notopus* Giesbr.
O. ornata Giesbr.
O. subtilis Giesbr.
O. venutas Philippi.
**Conæa rapax* Giesbr.
Corycæus (*Corycæus*) *crassiusculus* Dana (as *venustus* Dana).
**C.* (*C.*) *speciosus* Dana.
**Sapphirina iris* Dana (as *salpæ* (Claus)).
Ectinosoma melaniceps Boeck.
**Corina granulosa* Giesbr.
E. normani T. and A. Scott.
Microsetella norvegica (Boeck).
**M. rosea* Dana.
Euterpina acutifrons (Dana).
**Macrosetella gracilis* (Dana).
Clytemnestra rostrata (Brady).
**C. scutellata* Dana.
**Ægisthus mucronatus* Giesbr.
Æ. aculeatus Giesbr.

Of the above list of 51 species no less than 26, marked with an asterisk, have never, as yet, been recorded from the waters of the English Channel. From this latter region only 26 Indo-Pacific species have been recorded (*vide* Norman and T. Scott (1906), Ostenfeld (1906), and Marine Biological Association (1931)), namely :

Paracalanus parvus (Claus).
Clausocalanus arcuicornis (Dana).
†*Euchæta hebes* Giesbr.
Temora longicornis Baird.
T. stylifera (Dana).

Pseudocalanus obtusatus Brady and Robertson.
Candacia pectinata Brady.
Labidocera wollastoni (Lubb.).
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*A.*) *longiremis* (Lillj.).
Oithona nana Giesbr.
O. plumifera Baird.
O. similis Claus.
Oncœa mediterranea Claus.
O. minuta Giesbr.
O. ornata Giesbr.
O. subtilis Giesbr.
O. venusta Philippi.
†*Lubbockia aculeata* Giesbr.
†*L. squillimana* Claus.
Corycæus (*Corycæus*) *crassiusculus* Dana (as *venustus* Dana).
Ectinosoma melaniceps Boeck.
E. normani T. and A. Scott.
Euterpina acutifrons (Dana).
Microsetella norvegica (Boeck).
Clytemnestra rostrata (Brady).

Of the above, three have not been recorded from the Irish coast; these are marked with a † in the above list.

Farran (1920, p. 22) remarks, "The records of *Euchæta hebes* require special mention. This species is a regular inhabitant of the Atlantic Drift off the mouth of the English Channel, or, at any rate, that part of it which flows past Ushant, and might be expected to occur frequently on the west coast of Ireland. It has, however, not yet been met with in any of the numerous hauls of the mesoplankton trawl made to the W. and S.W. of Ireland by the Department's steamer, and the single records from T.III and T.IV are the only ones known to me from W. of 10° long. This seems to indicate that the 70 mile Fastnet station, where it has occurred on three occasions, is at times flooded by water from off the mouth of the English Channel with its rather peculiar admixture of neritic and oceanic forms, and gives further support to the theory . . . of a cyclonic circulation of the water south of Ireland." The comparative paucity of Indo-Pacific species in the English Channel is in all probability correlated with the hydrographic conditions that pertain in the area to the immediate west, and especially with the poor influx of oceanic and North Atlantic Drift water into the Channel. As Kemp (1939) has pointed out, Matthews, Harvey and others have shown that to the south of Ireland there is an extensive cyclonic movement of water that greatly influences the conditions off the entrance to the Channel, and Russell (1938, p. 415) points out that "this swirl varies in extent and position; at times it appears to block the mouth of the Channel and at others it apparently retreats farther north, thus laying the Channel mouth open to more oceanic water from the south and south-west." The amount of influx of oceanic water may thus vary considerably in different years, and it appears to have been much reduced in recent times. Kemp (1939) has also called attention to the fact that in recent times there has been a change

in the temperature of the sea-water in the north Atlantic region between Greenland and Bear Island, and that this has resulted in a change in the fauna of both the British Isles and Iceland. Such a rise of temperature would facilitate the transport of Indo-Pacific warm-water species into northern latitudes. (For further references to this subject I must refer the reader to Kemp's paper.) It is well known that variations in the temperature and salinity of the water off the coast of Europe are frequently experienced. According to the "transgression" theory of le Danois (1934) there is a periodic expansion of the warmer water of the North Atlantic: on the other hand, Iselin (1938) attributes these changes to alterations in the strength of the Gulf Stream, and he points out that a decrease in strength will be accompanied by a discharge of warm-water towards the north-east, and that "there is reason to believe that the warm saline water which from time to time seems to invade the European Coastal Areas arises more as a tongue than a current." Whatever the fundamental cause of these variations may be, there can be no doubt that such a movement of warm water will carry with it the corresponding fauna; as Bigelow (1931) has pointed out, "perhaps the best known example of broad scale transport to unfavourable regions is that of tropical pelagic organisms to fatally high latitudes by the agency of the Gulf Stream. And every gradation is to be seen in this respect, from sporadic drift of occasional individuals, far outside their normal ranges, to the opposite extreme, where a supply is so constantly brought from some far-off source that a permanent community is mechanically maintained in parts of the sea, where the species in question cannot reproduce itself."

As we pass northwards from the coast of Ireland to the north coast of Scotland and the neighbouring islands, Orkneys, Shetlands and Faroes, there seems to be a disappearance of quite a large number of species: and so far no specimens of any of the following species have been recorded from this northern region:

Mecynocera clausi Thompson.
Calocalanus pavo (Dana).
C. styliremis Giesbr.
Clausocalanus arcuicornis (Dana).
Scolecithricella dentata Giesbr.
Temora stylifera (Dana).
Labidocera kröyeri (Brady).
Temoropia mayumbæensis T. Scott.
Oncæa conifera Giesbr.
O. ornata Giesbr.
O. venusta Philippi.
Conæa rapax Giesbr.
Corina granulosa Giesbr.
Corycæus (Corycæus) crassiusculus Dana.
C. (C.) speciosus Dana.

Those species that have managed to survive up to this point may from now on take one of two routes: they may be carried either towards the north-east and so reach the North Sea and the coast of Norway, or they may be swept to the north-west towards Iceland and the coast of Greenland, and thence southwards again in the Labrador Current to the east coast of North America.

Taking the north-easterly current first, Wolfenden (1902, 1904) has recorded a number of species from the Faroe-Iceland Channel, and of these as many as 12 are known from the Indo-Pacific region, namely :

Rhincalanus cornutus Dana.
Paracalanus parvus (Claus).
Eucalanus crassus Giesbr.
Euchœta marina (Prestand.).
Scolecithricella minor (Brady).
Lucicutia flavicornis (Claus).
Candacia pectinata Brady (= *armata* Boeck).
Acartia (*Acartiura*) *clausi* Giesbr.
Oithona similis Claus (= *spinifrons* Boeck).
Oncœa mediterranea Claus.
O. subtilis Giesbr.
Microsetella norvegica (Boeck).

Other species that will probably be recorded sooner or later from this area, since they are already known to occur either in the North Sea or off the coast of Norway, are—

Pseudocyclops obtusatus Brady and Robertson.
Labidocera wollastoni (Lubb.).
Oithona plumifera Baird.*
O. nana Giesbr.
Paroithona parvula Farran.
Oncœa minuta Giesbr.
O. notopus Giesbr.
Sapphirina iris Dana.
Ectinosoma melaniceps Boeck.
Clytemnestra scutellata Dana.

A study of the surface currents shows how easily species living on the north coast of Scotland can be swept either into the North Sea and so reach the entrance to the Baltic Sea, or else pass direct to the coast of Norway. Records of the occurrence of species of Copepoda on the east coast of Scotland and England and in the North Sea have been made by Brady (1872), Timm (1894), T. Scott (1900, 1902), Norman and Brady (1909) and Pesta (1928). T. Scott (1902) has noted the occurrence on the north and east of Scotland of *Eucalanus crassus* Giesbr., and he remarks that this species " has on several occasions been taken on the Moray Firth. . . . Its occasional occurrence in the Moray Firth may therefore be owing to the action of currents passing round the north of Scotland into the North Sea. I have lately met with what looks like a southward extension of the distribution of the species on the east of Scotland, several specimens having been obtained in a tow-net gathering of Crustacea collected off Aberdeen, on November 11, 1901. This is the first time I have met with *Eucalanus crassus* so far south on the east coast." The species has been recorded from the North Sea in 1903 by Ostenfeld (1906).

* The occurrence of *Oithona plumifera* Baird, as far north as the Faroe Channel is open to doubt: it is possible that the examples recorded from the North Sea and the coast of Norway should be referred to *Oithona atlantica* Farran.

The gradual elimination of Indo-Pacific species as one passes northwards from the tropics into cold water appears to have rendered possible the evolution of a number of new species and even of new genera, and the following have been recorded from the region of the British Isles :

†*Calanus helgolandicus* (Claus).
†*C. hyperboreus* Kröyer.
†*Amallophora brevicornis* Sars.
A. echinata Farran.
†*Diaixis hibernica* T. Scott.
†*Microcalanus pusillus* Sars.
Stephus fultoni T. and A. Scott.
†*S. minor* T. Scott.
†*S. scotti* Sars (= *gyrans* T. Scott, *non* Giesbr.).
†*Parastephus pallidus* Sars.
Pseudocyclopia caudatas T. Scott.
P. crassicornis T. Scott.
†*P. giesbrechti* Wolfend.
P. minor T. Scott.
†*P. stephoides* Thompson.
†*Eurytemora affinis* (Poppe) (= *clausi* Hoeck, *lacinulatus* (Sars)).
†*E. velox* (Lillj.).
†*Pseudocyclops crassiremis* Brady.
Mimocalanus cultrifer Farran.
M. nudus Farran.
Candacia gracillimana Farran.
Phænna zetlandica T. Scott.
†*Pseudophænna typica* Sars.
†*Acartia* (*Acartiura*) *discaudata* (Giesbr.).
†*A.* (*A.*) *longiremis* (Lillj.).
A. (*Acanthacartia*) *bifilosa* (Giesbr.).
†*A.* (*Paracartia*) *grani* Sars.
†*Paramisophria cluthæ* T. Scott.
Oithona pelagica Farran.
†*Cyclopina elegans* T. Scott.
†*C. gracilis* Claus.
†*C. longicornis* Boeck.
†*C. littoralis* Brady.
Oncæa exigua Farran.
O. obscura Farran.
Lubbockia brevis Farran.
Ægisthus atlanticus Wolfend.
Æ. spinulosus Farran.*

* This species has been recorded by Wilson (1942) from the East Pacific area and from the North of Samoa. If this be correct, its distribution, like that of *Corycæus anglicus* Lubb., *Oncæa anglica* Brady, *O. similis* Sars, and *O. tenella* Sars, may perhaps be explainable on the grounds of the existence in Tertiary times of the channel across Central America (*vide supra*, p. 406).

Other species that seem to have had their origin in the tropical or temperate regions of the North Atlantic Ocean can have been swept eastward by the Gulf Stream and the North Atlantic Drift, and so may make their appearance on the coast of the British Isles. The following species have now been recorded :

Centropages chierchiæ Giesbr.
†*C. hamatus* (Lillj.).
†*C. typicus* Kröyer.
†*Isias clavipes* Boeck.
†*Anomalocera patersoni* Templ.
Pontella lobiancoi (Canu).
†*Parapontella brevicornis* (Lubb.).
†*Corycæus* (*Ditrichocorycæus*) *anglicus* Lubb.
†?*C.* (*Corycella*) *rostratus* Claus.*
†*Halithalestris krohni*.

In the south-east region of the North Sea the following Indo-Pacific species have been recorded (*vide* Timm, 1894 ; Ostenfeld, 1906 and 1916 · Pesta, 1928 ; and Wilson, 1942) :

Nannocalanus minor (Claus).
Paracalanus parvus (Claus).
Temora longicornis O. F. Müll.
Candacia pectinata Brady (= *armata* Boeck).
Labidocera wollastoni (Lubb.).
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*A.*) *longiremis* (Lillj.).
Oithona plumifera Baird (? = *atlantica* Farran).
O. nana Giesbr.
? *O. setigera* Dana.
O. similis Claus.
Oncæa conifera Giesbr.
O. subtilis Giesbr.
Sapphirina iris Dana.
Microsetella norvegica (Boeck).
Euterpina acutifrons (Dana).

From the North Sea a certain number of species have succeeded in getting into the western end of the Baltic Sea through the Skagerrak and Kattegat (*vide* Giesbrecht, 1882 ; Möbius, 1884 and 1887 ; Ostenfeld, 1906 and 1916 ; Jakubisiak, 1933 ; and Kunz, 1935), though the rapid reduction in the inner regions of this inland sea of the salinity of the water has prevented many of them establishing themselves in the central and northern regions of the Baltic Sea. I give below a list of these species and have indicated by the

* M. Dahl (1912) claims that this species is limited to the Atlantic Ocean and the Mediterranean Sea, and that the records of its occurrence in the Pacific and Indian Oceans is due to faulty identification. It has however, been recorded from the Pacific Ocean by Farran (1929) and Wilson (1942).

letters S (Skagerrak). K (Kattegat) and B (Baltic Sea) the region to which they have been able to penetrate :

Paracalanus parvus (Claus)—S, K and B.
Scolecithricella minor (Brady)—S.
Temora longicornis (O. F. Müll.)—S, K and B.
Candacia pectinata Brady—S and K.
Labidocera wollastoni (Lubb.)—S and K.
Acartia (*Acartiura*) *clausi* Giesbr.—S and K.
A. (*Acanthacartia*) *bifilosa* (Giesbr.)—S and K.
A. (*Acartiura*) *longiremis* (Lillj.)—S, K and B.
A. (*Acanthacartia*) *tonsa* Dana—S, K and B.
Oithona nana Giesbr.—S and K.
O. plumifera Baird—S and K.
O. similis Claus—S, K and B.
Oncæa conifera Giesbr.—S.
O. minuta Giesbr.—S.
O. subtilis Giesbr.—S.
Microsetella norvegica (Boeck)—S, K and B.
M. rosea Dana—K.
Euterpina acutifrons (Dana)—S.

All of the above species have been recorded from the Indo-Pacific region. In addition several Atlantic Ocean or British species have also been carried in, namely :

Calanus finmarchicus Gunn—S and K.
C. hyperboreus Kröyer—S.
Microcalanus pusillus Sars—S and K.
Pseudocalanus elongatus Boeck—S, K and B.
Centropages hamatus (Lillj.)—S, K and B.
C. typicus Kröyer—S and K.
Isias clavipes Boeck—S.
Eurytemora affinis (Poppe)—S.
Anomalocera patersoni Templ.—S and K.
Acartia (*Acartiura*) *discaudata* (Giesbr.)—S, K and B.
Corycæus (*Ditrichocorycæus*) *anglicus* Lubb.—S and K.
Cyclopina gracilis Claus—B.

I have (*vide supra*, p. 483) given a list of those species that appear to have their origin in the North Atlantic Ocean or round the coasts of the British Isles ; if these species follow the same dispersal routes that I have already indicated for the Indo-Pacific species, we should expect to find many, if not most of them on the coast of Norway, and as many as 29 of these species, which I have indicated in the lists by a †, have been recorded from Norwegian waters.

Our knowledge of the Copepoda of Norway is very extensive, thanks to the work of G. O. Sars (1901–03, 1903–11, 1913–18 and 1919–21). Some 61 species have been recorded from the epiplankton, and of these the following are known to be Indo-Pacific forms :

Paracalanus parvus (Claus).
**Scolecithricella minor* (Brady).
**Pseudocyclops obtusatus* Brady and Robertson.
**Temora longicornis* Baird.
**Candacia pectinata* Brady (= *armata* Boeck).
**Labidocera wollastoni* (Lubb.).
**Acartia* (*Acartiura*) *clausi* Giesbr.
**A.* (*A.*) *longiremis* (Lillj.).
**Oithona atlantica* Farran (= *spinirostris* Claus).
**O. plumifera* Baird (? = *atlantica* Farran).
**O. similis* Claus (= *helgolandica* Claus).
Paroithona parvula Farran.
? **Oncæa conifera* Giesbr.
**O. minuta* Giesbr.
**O. notopus* Giesbr.
Sapphirina iris Dana.
**Ectinosoma melaniceps* Boeck.
E. normani T. and A. Scott.
**Microsetella norvegica* (Boeck).
Euterpina acutifrons (Dana).
Clytemnestra scutellata Dana.

A number of these species have survived even colder conditions, and have been recorded from Arctic waters (*vide* T. Scott, 1899 ; T. and A. Scott, 1901 ; Mrazek, 1902 ; Linko, 1907 ; and Farran, 1936*b*) ; these are indicated in the above list by an asterisk. To the list of Indo-Pacific species that have been taken in Arctic waters must be added *Oncæa mediterranea* Giesbr. (*vide* T. Scott, 1899, and Mrazek, 1902), though this species has, so far, not been recorded from the coast of Norway.

The proportion of Indo-Pacific species in these northern latitudes thus shows a marked fall, and they constitute only some 30 per cent. of the total number.

Several other surface-living Atlantic forms appear to have suffered the same fate, and have been swept northwards into Arctic regions, namely :

Euchæta wilsoni Jespersen,
Centropages hamatus (Lillj.),
Anomalocera patersoni Templ.,
? *Pontella atlantica* (M.E.),
Acartia (*Acanthacartia*) *bifilosa* (Giesbr.),
Tortanus discaudatus Thompson and A. Scott,
Cyclopina gracilis Claus,

and perhaps to these should be added—

Oncæa anglica Brady,
O. similis Sars,
O. tenella Sars,

which have been recorded from the northern regions of both the Atlantic and Pacific Oceans, and may have made their way from one to the other *via* the Arctic Ocean.

Those species that have been swept by the north-westerly branch of the North Atlantic Drift towards Iceland and Greenland and beyond must have been able to survive a considerable fall in the temperature of the water; even so we still find several species of Indo-Pacific origin in this area, and the following have been recorded by Jespersen (1934, 1939*a*, and 1939*b*), With (1915) and Wilson (1942):

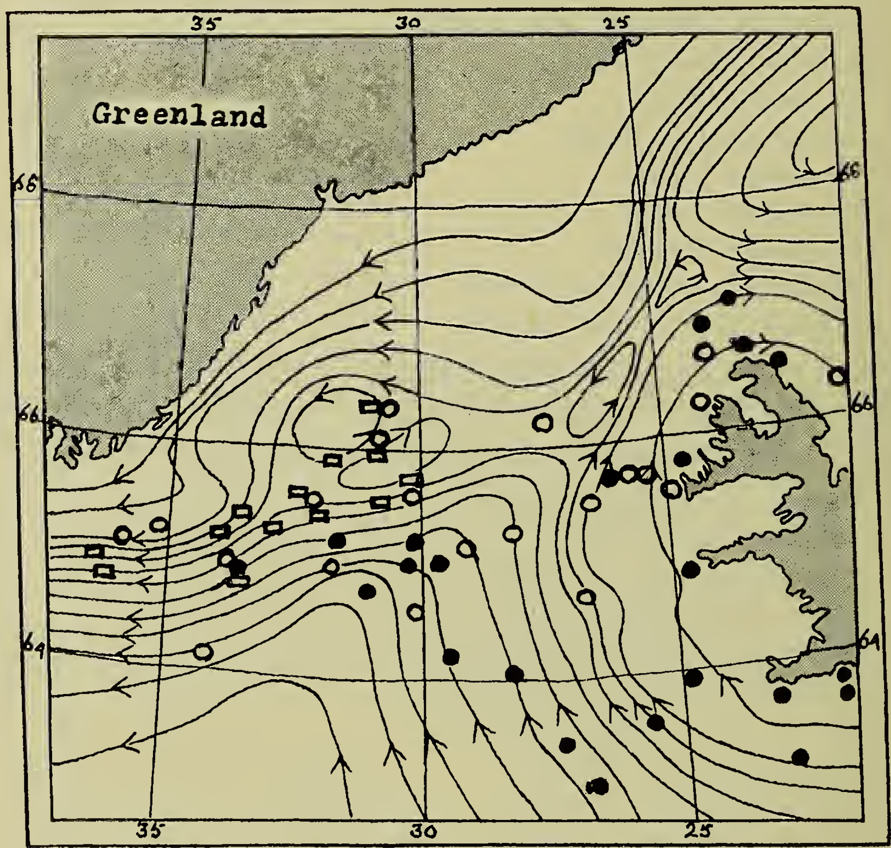
Paracalanus parvus (Claus).
Eucalanus crassus Giesbr.
Clausocalanus arcuicornis (Dana).
Euchæta acuta Giesbr.
E. hebes Giesbr.
Scolecithricella minor (Brady).
Temora longicornis (Müll.).
Acartia (*Acartiura*) *clausi* Giesbr.
Oithona atlantica Farran.
O. similis Claus.
Oncæa conifera Giesbr.
O. minuta Giesbr.
O. notopus Giesbr.
O. venusta Philippi.
Ectinosoma melaniceps Boeck.
Microsetella norvegica (Boeck).

All of these, with the exception of *Temora longicornis* (Müll.) and the species of *Oncæa*, are present on both east and west sides of Greenland. Jespersen (1940) and Wilson (1942) have recorded the following species from the area to the south of Iceland:

Calanus finmarchicus (Gunn.).
C. helgolandicus (Claus).
Nannocalanus minor (Claus).
Paracalanus parvus (Claus).
Clausocalanus arcuicornis (Dana).
Pseudocalanus minutus Kröyer.
Microcalanus pygmæus Sars.
Scolecithrix danæ (Lubb.).
Centropages hamatus (Lillj.).
Temora longicornis Baird.
Anomalocera pattersoni Templ.
Labidocera wollastoni (Lubb.).
Pontella lobiancoi Canu.
Acartia (*Acartiura*) *clausi* Giesbr.
A. (*Acanthacartia*) *bifilosa* (Giesbr.).
A. (*A.*) *longiremis* (Lillj.).
Oithona atlantica Farran.
O. nana Giesbr.
? *O. plumifera* Baird (? = *atlantica* Farran).
O. setigera Dana.
O. similis Claus.

Oncæa borealis Sars.
O. conifera Giesbr.
O. venusta Philippi.
Microsetella norvegica (Boeck).
Clytemnestra rostrata (Brady).

Jespersen (1934, p. 49) has noted that specimens of *Paracalanus parvus* were present in the area to the south-west of Iceland in the surface layer, but that in the Labrador Sea to the south of Davis Strait they were only taken in deeper water, when the nets were fished with 1000–2500 m. of wire out. He estimates that this length of wire corresponds to a depth of the net of about one-half to two-thirds this distance, namely, to depths of from 500 to 1670 m. Smith, Soule and Mosby (1937) have pointed out that the East Greenland



TEXT-FIG. 88.—Chart of the Irminger Current (after Nansen), showing the position of Stations where certain Copepoda were captured. ● = *Scolecithricella minor* (Brady). ▭ = *Pseudocalanus minutus* (Kroyer). ○ = *Microsetella norvegica* (Boeck).

Arctic Current and a western branch of the Irminger Current, on rounding Cape Farewell, are renamed the West Greenland Current, and that this flows northwards and then branches, part crossing Davis Strait ridge into Baffin Bay, and part flowing westward on the south side of Davis Strait ridge to join Arctic water that is flowing southwards out of Baffin Bay to produce the Labrador Current. They also show that the warm salty West Greenland water progressively sinks as it proceeds northwards and then westwards and finally southwards, spreading out as it goes to form the intermediate water of the Labrador Sea between

some 500 and 2000 m. depth. Such an admixture of water provides a reasonable explanation of the occurrence of *Paracalanus parvus* (Claus) in the Labrador Sea at the depths given above. A comparison of the occurrence of *Scolecithricella minor* (Brady) and *Microsetella norvegica* (Boeck) and the main course of the Irminger Current, as shown by Nansen (*vide* Text fig. 88) leaves little doubt that these species, like *Paracalanus parvus*, are swept westward into the Labrador Sea by the Irminger Current, whereas *Pseudocalanus minutus* Kröyer appears to be swept southwards from the Arctic region in the East Greenland Current.

From Baffin Bay along the North American Coast as far south as Chesapeake Bay, in lat. 38° N., a belt of cold water separates the coast from the warm water of the Gulf Stream and the North Atlantic Drift. Passing out of Baffin Bay is the Labrador Current, but it is doubtful whether this actually reaches further south than the coast of Nova Scotia; beyond this in the region of the Gulf of Maine the cold water is probably derived from a different source. Bigelow (1924) remarks, "The low temperature of the surface water near shore, contrasted with the 'Gulf Stream' offshore and with the oceans as a whole at the latitude in question, naturally suggests a northern origin until analysed in relation to other factors. . . . The south-westerly drift that has been reported repeatedly along the coasts of the north-eastern United States and Nova Scotia argues in the same direction: so, also, the extension of a generally boreal fauna southward and westward as far as Cape Cod, with planktonic communities of this category spreading still farther in this direction in winter." Bigelow, however, maintains that the Labrador Current does not reach, much less skirt, the coast of North America from Nova Scotia southwards as a regular event. He attributes this cold water to the effect of melting of the ice from the Gulf of St. Lawrence: "it is to this cold band skirting Nova Scotia that the name 'Nova Scotia current' is applied. . . . During the spring a large volume of water enters the eastern side of the Gulf of Maine from this source." Thanks to the work of Wheeler (1900), Sharpe (1911), Sumner, Osburn and Cole (1911), Willey (1919, 1932), Fish (1925), Wilson (1932*a* and *b*), Bigelow and Sears (1939) and Nicholls (1940), we now possess considerable knowledge of the Copepod fauna of this coastal region. In all, some 85 species of Epiplanktonic Copepods have been recorded, and among these the following are known from the Indo-Pacific region:

Nannocalanus minor (Claus).
Undinula vulgaris (Dana).
Eucalanus crassus Giesbr.
E. monachus Giesbr.
Rhincalanus cornutus Dana f. *atlantica* Schmaus.
Mecynocera clausi Thompson.
**Paracalanus parvus* (Claus).
Calocalanus pavo (Dana).
C. plumulosus (Claus).
**Clausocalanus arcuicornis* (Dana).
Euchæta marina (Prestand.).
Scolecithrix danae (Lubb.).
**Scolecithricella minor* (Brady).
Centropages bradyi Wheeler.
C. violaceus Brady.

Temora longicornis Baird.
T. stylifera (Dana).
T. turbinata (Dana).
Candacia pectinata Brady (= *armata* Boeck).
C. pachydactyla Dana.
C. simplex Giesbr.
C. varicans Giesbr.
Labidocera acutifrons (Dana).
L. nerii (Kröyer).
Pontella securifer Brady.
P. spinipes Giesbr.
Pontellopsis regalis (Dana).
P. villosa Brady.
Pontellina plumata Dana.
**Acartia* (*Acartiura*) *clausi* Giesbr.
**A.* (*A.*) *longiremis* (Lillj.).
A. (*Acanthacartia*) *tonsa* Dana.
A. (*Planktacartia*) *danae* Giesbr.
**Oithona atlantica* Farran.
O. brevicornis Giesbr.
O. nana Giesbr.
O. plumifera Baird.
**O. similis* Claus.
Oncœa conifera Giesbr.
**O. minuta* Giesbr.
O. venusta Philippi.
Corycœus (*Corycœus*) *crassiusculus* Dana.
C. (*C.*) *speciosus* Dana.
C. (*Monocorycœus*) *robustus* Giesbr.
C. (*Agetes*) *flaccus* Giesbr.
C. (*Ditrichocorycœus*) *lubbocki* Giesbr.
C. (*Corycella*) *carinatus* Giesbr.
C. (*C.*) *rostratus* Claus.
Sapphirina angusta Dana.
S. auronitens Claus—*sinuicauda* Brady.
S. nigromaculata Claus.
S. ovatolanceolata Dana—*gemma* Dana.
S. scarlata Giesbr.
Copilia mirabilis Dana.
**Microsetella norvegica* (Boeck).
M. rosea Dana.
Macrosetella gracilis (Dana).
M. oculata Sars.
Miracia efferata Dana.
Clytemnestra rostrata (Brady).
Ægisthus mucronatus Giesbr.

We thus find as many as 61 Indo-Pacific species, forming some 72 per cent. of the epiplanktonic population, in this cold belt. A few of these species, which I have indicated in the above list by means of an asterisk, may have been carried southward in the Labrador and Nova Scotia currents; and along these same currents certain boreal or even Arctic species appear to have been swept southward, such as—

Pseudocalanus minutus Kröyer.
Centropages hamatus (Lillj.).
C. typicus Kröyer.
Eurytemora affinis (Poppe).
E. herdmani Thompson and A. Scott.
Tortanus discaudatus Thompson and A. Scott.
Acartia (*Acartiura*) *discaudata* (Giesbr.).
A. (*Acanthacartia*) *bifilosa* (Giesbr.).
Oncæa borealis Sars.
Ectinosoma neglectum Sars.

It seems probable, however, that the great majority of warm-water species must have reached the coast by passing from the Gulf Stream across the sub-polar convergence zone into the cold water along the coastal belt.

Willey (1932) pointed out that a number of species, that had been recorded by T. Scott (1894) from the Gulf of Guinea, have also been taken in the Great Acadian Bight between Cape Cod and Cape Race, and he gives a list of 15 such species and contrasts the frequency with which they were taken in this region with the comparative rarity of 12 other species, which he terms "endemic" in the Gulf of Guinea. Unfortunately he has paid no attention to the depth at which these latter species normally live, so that in his list of so-called "endemic" species there are no less than 11, which are deep-dwellers and have been taken in either the Indian or Pacific Oceans or in both. Wilson (1932*b*) has noted that a number of species taken in the Chesapeake Bay area were found only in the outside oceanic region along the 100-fathom line, and Bigelow and Sears (1939) in their studies of the zoo-plankton of the American coast between Cape Cod and Chesapeake Bay have noted the occurrence of several tropical species, particularly in the off-shore zone in about 200 m. of water, and they attribute this to the occasional transgression of warm off-shore water; among the surface-living species that they cite as immigrants into the continental region from off-shore are the following:

Nannocalanus minor (Claus),
Undinula vulgaris (Dana),
Mecynocera clausi Thompson,
Scolecithrix danæ (Lubb.),
Centropages violaceus (Claus),
Candacia pectinata Brady (= *armata* Boeck),

and certain species of the genus *Sapphirina*. They also include a number of deep-dwelling species belonging to the genera *Eucalanus*, *Euchirella*, *Pleuromamma* and *Rhincalanus*.

A similar extension of the range of tropical species along the north-east coast of America is shown by the Algæ ; Taylor (1937) has given a list of 14 species of tropical algæ found in this coastal region, but a study of his monograph shows that, in addition to these, there are 18 other species that appear to have reached the coast from the tropics, 22 warm water species that seem to have spread northwards from Florida, and 13 species that are known from Bermuda. The explanation of the occurrence of these warm-water and tropical species, whether animal or plant, along the American coast appears to lie in the mechanics of the Gulf Stream. Redfield (1936) has called attention to a paper by Rossby (1936), which points out that in the Gulf Stream there is an absorption of water on the right side of the Current that must be derived from the Antilles Current, which is itself a continuation of the North Equatorial Current, and a discharge of water on the left side into the coastal zone ; hence, as Rossby points out (*loc. cit.*, p. 24), " Through this upstream absorption along the right edge combined with the downstream discharge of eddies along the left edge, water may be transferred across the current from the open ocean basin to the right into the limited body of water to the left of the current." Redfield points out that " Rossby's study suggests that the absorption of oceanic water into the Gulf Stream takes place chiefly south of the latitude of Chesapeake Bay ; the discharge of this water at a lesser depth occurs from Cheapeake Bay to at least Nova Scotia." Although Redfield is concerned with the transfer of chemical nutrient substances dissolved in the water, such a movement must also carry with it some at least of the Zoo- and Phyto-plankton, and it seems highly probable that the presence of so many tropical and warm-water species on this part of the North American coast, which is bathed by cold water coming down from the north-east, is to be accounted for in this way. Church (1937) has given an account of these extensions of Gulf Stream water, and states that " a warm mass will appear quite suddenly and spread over a fairly large area with great rapidity. . . . The trend of the isotherms shows the mass to be thumblike in shape. . . . The pattern is thus indicative of an eddy or whirl. . . . On the charts these water masses appear as offshoots from the warm water of the Gulf Stream " ; and he draws attention to the fact that these water masses correspond to the " transgression " of Le Danois. Bigelow (1924, p. 836) has remarked that " small amounts of ' Gulf Stream ' water have long been known to drift inward towards the sector of coast line bounded on the east by Martha's Vineyard and on the west by Narragansett Bay, during most summers, bringing with them a typically tropical fauna of fishes, planktonic invertebrates and Gulf Weed (Sargassum)." This " migration " of warm-water species along the American coast has been noted by numerous observers, and Fish and Johnson (1937) have shown that even as far north as the Bay of Fundy and the Gulf of Maine " tropical communities enter the gulf sporadically during the summer, usually between April and September, and successive waves may be composed of quite different associations depending on the nature of the stock in the Gulf Stream at the time." There is, however, still another route by which a number of these " tropical " species can eventually reach the American coast ; Iselin (1934) has drawn attention to the fact that, although the Gulf Stream is a warm water current, some at least of the water in it is derived from the Sub-Polar Antarctic intermediate water. The absorption of water from this cold stream must carry with it some of the plankton, and among the species that are common to the tropical warm water and the West Wind Drift and which could be carried northwards by the Sub-Polar Intermediate Current and so reach the American coast are the following species ;

Nannocalanus minor (Claus),
Mecynocera clausi Thompson,
Paracalanus parvus (Claus),
Calocalanus pavo (Dana),
C. styliremis Giesbr.,
Clausocalanus arcuicornis (Dana),
Euchæta marina (Prestand.),
Scolecithricella minor (Brady),
Centropages violaceus (Claus),
Temora turbinata Dana,
Labidocera acutifrons (Dana),
Acartia (*Acartiura*) *clausi* Giesbr.,
A. (*Planktacartia*) *danæ* Giesbr.,
Oithona plumifera Baird,
O. similis Claus,
Oncæa conifera Giesbr.,
Corycæus (*Corycæus*) *speciosus* Dana,
C. (*Corycella*) *rostratus* Claus,
Sapphirina scarlata Giesbr.,
Microsetella norvegica (Boeck),
M. rosea Dana,
Macrosetella gracilis (Dana),
Clytemnestra rostrata (Brady),

and to these we may perhaps add *Drepanopus pectinatus* Brady, which has been recorded by Wilson (1942) in the "Carnegie" collection from lat. 44° 39′ N., long. 33° 06′ W., at 100 m. depth.

A few species appear to have had their origin in this region of the American coast, namely :

Pseudodiaptomus coronatus Williams.
Eurytemora americana Williams (= *E. transversalis* Campbell, *E. kieferi* Sumner).
E. herdmani Thompson and A. Scott.
Euchæta wilsoni Jespersen.
Labidocera æstiva Wheeler.
Pontella meadi Wheeler.
P. pennata Wilson.
Tortanus setacaudatus Williams.
Acartia forcipata Thompson and A. Scott.
Cyclopina agilis Wilson.
C. laurentica Nicholls.
C. vachoni Nicholls.

As, up to the present time, none of these species has been taken elsewhere, it seems justifiable to regard them as being endemic.

The Distribution of the Meso- and Bathy-Planktonic Species.

Since the movement of the surface currents appears to provide an adequate explanation of the distribution of the plankton of the upper levels of the ocean, it would appear probable that the movement of the sub-surface masses of water will provide an equally adequate explanation of the distribution of those species that inhabit either the intermediate or bottom water ; and, furthermore, if, as we have seen, the surface water can be divided into biological regions owing to the differences in the plankton of the various surface currents, it is only reasonable to expect that we shall also find similar differences in the deeper currents. Our knowledge of the movements of the deep masses of water is still incomplete, but the recent work of the " Meteor " in the Atlantic Ocean, the " Discovery " in the Antarctic, the " Dana" and the " Mabahis " in the Indian Ocean and the " Carnegie " in the Pacific has added considerably to the achievements of previous expeditions, and has demonstrated at least the chief features of this circulation. In Chart II I have attempted to indicate the main lines along which the water masses move at different depths.

Hentschel (1929) has put forward the view that the distribution of the Oceanic Plankton in the upper levels is determined by two factors, namely, the supply of nutrient materials and the distribution of these by horizontal and vertical currents, and in consequence of this he claims that in each area the density of the deep-dwelling plankton corresponds to the quantity of organisms living on the surface. In this connection it must, however, be borne in mind that the distribution of the food-supply and the plankton in these deeper levels must follow the movement of the water in those levels and not the direction of the surface currents. Steuer (1931) also attempted to correlate the distribution of the plankton with that of the nutrient salts, especially the phosphates, in the surface water, and he has given a chart (*loc. cit.*, p. 469, fig. i) showing the distribution in the Atlantic Ocean of the two species of the genus *Rhincalanus*, namely, *R. nasutus* Giesbr. and *R. gigas* Brady. He claims that the distribution of the former species shows two maxima, one in the region of the Cape Verde Islands and the other off the west coast of Africa respectively. Hentschel (1937, p. 153), in an Appendix to Steuer's Report (1937) on the distribution of several genera in the South Atlantic Ocean, claims that the fertility of these two regions is due to the increased Nannoplankton content, and that this in turn can be attributed to upwelling water off the African coast. It seems to me that a rich food-supply in any given area can, at any rate in the main, only affect the total number of individuals that are living there and have but little effect on the number of species, though any upwelling current that brings with it an increased amount of nutrient material and so renders possible an increase in the Phytoplankton may also import species that are normally to be found in the deeper levels.

In many localities the composition of the planktonic fauna, and particularly of the Copepoda, has been attributed to local hydrographic conditions, and in this connection it must be borne in mind that the configuration of the sea-floor has a direct influence on the direction and extent of flow of the bottom currents, and it is more than probable that even the mid-water currents are to some extent indirectly influenced by the bottom topography.

Commencing with the Arctic fauna, Mrazek (1902) has noted that individual Arctic species of Copepods have been found to penetrate southwards into the sub-Arctic region—

for instance, on the Norwegian coast ; and Lysholm and Nordgaard (1921) adopted " the conception of an intimate connection between currents and planktonic animals." Jespersen (1924) reached the same conclusion, and pointed out that a number of species that were previously considered to be Arctic " penetrate in reality far down into the Atlantic. It must, however, be stated as regards these that in the more southerly latitudes they are most often found in great depths where the temperature is low, whereas in the Arctic seas they are often found in the upper layers of water. The occurrence of such ' Arctic ' copepods in the great depths in the central parts of the Atlantic must undoubtedly be ascribed to the cold bottom water which has conveyed the organisms from the Arctic areas." It is a matter of some difficulty to decide which species are to be considered as truly Arctic, since one is always faced with the possibility that species may have originated in the North Atlantic area and have been carried thence into northern waters. Lysholm and Nordgaard (1921) have pointed out that the Wyville-Thompson Ridge (550 m.), the Faroe-Iceland Ridge (500 m.) and the Iceland-Greenland Ridge (*ca.* 550 m.) form a barrier to the northward penetration of Atlantic species, and hence " we cannot expect to find Atlantic deep-sea forms in the Norwegian Sea, as the separating ridges are comparatively high, and cold water flows over these ridges into the Atlantic." Similarly Jespersen (1934) has pointed out that " the cold water in Baffin Bay undoubtedly forms a barrier against the penetration northwards of several species, but besides this the submarine ridge in the Davis Strait is so prominent that it must certainly prevent many pronounced deep water species from extending further north." It would thus appear probable that at least the great majority of species that have been taken in the Arctic Ocean have had their origin in these northern waters. Mrazek (1902) has given a list of those species which he believes to be true Arctic forms, and to this certain other species have been added (*vide* T. Scott, 1901, and Sars, 1909). It seems probable that the great majority of the following are true Arctic species :

**Calanus cristatus* Kröyer,
**C. finmarchicus* (Gunn.),
**C. hyperboreus* Kröyer,
**C. tonsus* Brady,
**Pseudocalanus elongatus* (Boeck) (*sensu lato*),
**Microcalanus pygmaeus* Sars (= *pusillus* Sars),
**Ctenocalanus vanus* Giesbr.,
**Spinocalanus abyssalis* Giesbr. (= *longicornis* Sars),
**S. magnus* Wolfend. (= *spinosus* Farran),
S. schaudini Mrazek (? = *abyssalis* Giesbr.),
? **Ætideopsis multiserrata* Wolfend. (= *Chiridius nastus* With, *Ætideopsis rostrata* A. Scott *non* Sars),
Chiridius armatus Boeck,
C. modestus With,
**C. obtusifrons* Sars (= *Ch. armatus* Sars *non* Boeck),
**Bradyidius armatus* (Vanhöffen) (= *Undinopsis similis* Sars),
Drepanopsis bungei Sars,
Bradyetes brevis Farran,
Undinella oblonga Sars,

**Gaidius brevispinus* (Sars) (= *major* Wolfend.),
**G. tenuispinus* (Sars) (= *borealis* Wolfend.),
Undeuchæta spectabilis Sars,
Paraeuchæta farrani (With),
**P. glacialis* (Hansen),
**P. norvegica* (Boeck),
Scolecithrix römeri Mrazek,†
Neoscolecithrix farrani Smirnov,
**Xanthocalanus hirtipes* Vanhöffer (= *borealis* Sars),
X. propinquus Sars,
**Scaphocalanus brevicornis* (Sars) (= *gracilis* (Farran)),
**S. magnus* (T. Scott) (= *acrocephalus* Sars),
Eurytemora americana Williams (? = *thompsoni* Willey),
E. canadensis Marsh,
E. grimmi (Sars),
E. herdmani Thompson and A. Scott,
E. johanseni Willey (? = *pacifica* Sato),
E. raboti Richard,
E. tolli Rylov,
**Metridia longa* (Lubb.),
**Heterorhabdus norvegicus* (Boeck) (? = *abyssalis* Giesbr.),
**Haloptilus acutifrons* (Giesbr.),
**H. spiniceps* Sars,
**Augaptilus glacialis* Sars (= *zetesios* Wolfenden),
Temorites brevis Sars,
Limnocalanus grimaldii de Guerne,
L. macrurus Sars,
Centropages mcmurrichi Willey,
**Candacia norvegica* Boeck,
Paralabidocera amphitrite McMurrich,
Acartia tumida Willey,
Mormonilla polaris Sars,
Oncæa borealis Sars,

and perhaps to these should be added *Undeuchæta incisa* Esterly (*Pseudochirella superba* (With)), which has been taken in the Faroe-Iceland Channel, between Iceland and Greenland and off West Greenland.

In addition to the above, Farran (in Russell, 1935) gives *Acartia longiremis* (Lillj.) as Arctic and *Metridia lucens* Boeck, *Heterorhabdus compactus* Sars and *Candacia falcifera* Farran (= *magna* Sewell) as epiplanktonic Bipolar species, but I am inclined to regard the distribution of these species in northern waters as boreal-Atlantic rather than as truly Arctic ; and according to Steuer (1923) *Acartia longiremis* is a North Atlantic boreal species, occurring off the Norwegian coast, in the Barents Sea, around Iceland, on the west

† According to Brady (1918, p. 23) this species is synonymous with *S. glacialis* Giesbrecht, from the Antarctic region ; With (1915, p. 207) is " fairly convinced that it is identical with *Scolecithricella minor* (Brady)."

coast of Greenland and in the Labrador Current, but Wilson (1932) records it in the Gulf of Maine and (1942) in the Sargasso Sea, the Caribbean region and in the Pacific Ocean north of Samoa.

Of the above Arctic species some appear to be essentially epiplanktonic, while others are littoral or even fresh-water inhabitants : but 33 species have been taken in deep water, and of these no less than 26, marked in the above list with an asterisk, have been carried southwards into the North Atlantic Ocean and some have got considerably further ; thus *Calanus finmarchicus* (Gunn.), *C. tonsus* Brady, *Pseudocalanus elongatus* (Boeck), *Microcalanus pygmæus* Sars, *Ctenocalanus vanus* Giesbr., *Spinocalanus abyssalis* Giesbr., *S. magnus* Wolfend., *Gaidius tenuispinus* (Sars), ? *Scolecithrix römeri* Mrazek, *Scaphocalanus magnus* (T. Scott) and *Metridia longa* (Lubb.) have reached the Sub-Antarctic and even Antarctic region. *Calanus finmarchicus* (Gunn.), *Spinocalanus magnus* Wolfend., *Bradyidius armatus* (Vanhöffen), *Gaidius tenuispinus* (Sars), *Metridia longa* (Lubb.), *Scaphocalanus magnus* (T. Scott), *Xanthocalanus hirtipes* Vanhöffen and *Haloptilus acutifrons* (Giesbr.) have been taken in the Indian Ocean, and to these should be added *Heterorhabdus norvegicus* (Boeck), if I am correct in regarding this species as identical with *H. abyssalis* Giesbr., and *Candacia norvegica* Boeck, which is represented in Indian waters by a variety, *tropica* Sewell. *Calanus finmarchicus* (Gunn.), *C. hyperboreus* Kröyer, *C. tonsus* Brady, *Pseudocalanus elongatus* (Boeck), *Microcalanus pygmæus* Sars, *Ctenocalanus vanus* Giesbr., *Spinocalanus abyssalis* Giesbr., *S. magnus* Wolfend., *Gaidius tenuispinus* (Sars), *Metridia longa* (Lubb.), *Haloptilus acutifrons* (Giesbr.), *H. spiniceps* (Giesbr.), *Scaphocalanus magnus* (T. Scott) and *Heterorhabdus norvegicus* (Boeck) (= *abyssalis* Giesbr.) have been taken in the North Pacific Ocean, and with the exception of *Calanus hyperboreus* Kröyer have been also recorded from the South Pacific, where yet another Arctic species, *Calanus tonsus* Brady, has been taken.

As Mrazek (1902) has pointed out, such evidence as we at present possess indicates that the true Arctic species have a circum-polar habitat, and this is also probably true of those North Atlantic species that have been carried into the Arctic regions and have been able to survive and reproduce in these northern latitudes. If this be conceded, we should expect to find that some of these Arctic species have been swept southwards through the Bering Strait into the north-western part of the Pacific Ocean by the Oya-sio Current, and this would account for the presence in the Japanese area of the following Arctic species, recorded by Marukawa (1921) and Tanaka (1937) :

Calanus cristatus Kröyer,
Pseudocalanus minutus Kröyer (= *elongatus* Boeck),
Microcalanus pygmæus Sars (= *pusillus* Sars),
Ctenocalanus vanus Giesbr.,
Spinocalanus abyssalis Giesbr.,
Gaidius tenuispinus Sars,
Metridia longa (Lubb.),

and those from the extreme north of the Pacific Ocean in the vicinity of the Aleutian Islands, recorded by Wilson (1942) :

Calanus cristatus Kröyer,
C. finmarchicus (Gunn.),
C. hyperboreus Kröyer,

Pseudocalanus minutus (Kröyer) (= *elongatus* Boeck),
Ætideus armatus Brady,
Gaidius tenuispinus (Sars),
Metridia longa (Lubb.),
Acartia longiremis (Lillj.),

and perhaps to these should be added *Drepanopsis* sp., recorded by Marukawa from Japanese waters, if this be the same species as *D. bungei* Sars.

The next mass of water to be considered arises in the Northern Hemisphere, and to a large extent fills the North Atlantic basins lying respectively to the west and east of the mid-Atlantic ridge. The main mass of this water originates by a sinking down of the surface water between lats. 20° and 60° N., and this is joined by a deep current of Arctic water that is flowing southward from Baffin's Bay through Davis Strait (*vide* Wüst, 1928); at first the main mass of this North Atlantic Intermediate water, in which it is possible to detect several different hydrographic strata, collects under the influence of the spin of the earth along the American coast, where it lies at a depth of 1500 down to 4000 m., the main stream being between 2000 and 3000 m. In about lat. 20° N. this great stream is still further augmented by a mass of water that has flowed in a deep current out of the Mediterranean Sea and has drifted in a south-west direction across the North Atlantic (*vide infra*, p. 509). Nordgaard has suggested that areas, such as the North Atlantic, where warm and cold currents meet, and which he terms "boundary areas," are centres of species building and that, if this be so, these areas will also be centres of species distribution; and Lysholm and Nordgaard (1921) have commented on the way in which the currents meet in the North Atlantic and the large number of species of Copepoda that have been described from the North Atlantic Slope. Thanks to the work of several zoologists, among whom may be mentioned Giesbrecht, Sars, Farran, Wolfenden and Rose, we now possess a much better knowledge of the fauna of this area than that of either the Indian or Pacific Oceans. I have been able to collate a list of some 357 species of deep-sea Copepoda that have been taken in this area, and it seems probable that the great majority of these have actually originated in this region.

**Calanus finmarchicus* (Gunn.).
C. helgolandicus Claus.
C. hyperboreus Kröyer.
C. tenuicornis Dana.
Calanoides brevicornis (Lubb.) (= *Calanus carinatus* Kröyer).
Neocalanus gracilis (Dana).
N. robustior (Giesbr.).
Megacalanus princeps Wolfend.
Bathycalanus bradyi (Wolfend.).
B. princeps Farran (= *rigidus* Sars).
B. richardi Sars.
Bradycalanus sarsi (Farran).
Eucalanus attenuatus (Dana).
E. crassus Giesbr.
E. elongatus (Dana)
E. longiceps Matthews (= *acus* Farran).

Rhincalanus nasutus Giesbr.
Clausocalanus arcuicornis (Dana).
C. pergens Farran.
**Pseudocalanus elongatus* (Boeck).
**Ctenocalanus vanus* Giesbr.
**Spinocalanus abyssalis* Giesbr. and var. *pygmæa* Farran.
S. angusticeps Sars.
S. caudatus Sars.
S. hirtus Sars.
S. horridus Wolfend.
**S. magnus* Wolfend. (= *spinosus* Farran).
S. validus Sars.
Drepanopsis frigidus Wolfend. (= *Farrania oblonga* Sars).
D. pectinatus Brady.
Mimocalanus cultrifer Farran.
M. major Sars.
Isocalanus major Wolfend.
I. minor Wolfend.
Monacilla tenera Sars (= *Hypsicalanus gracilis* Wolfend.).
M. typica Sars (= *dubia* A. Scott, *Oxycalanus spinifer* Farran, *O. semispinus* A. Scott, *O. gracilis* Wolfend.).
Ætideus armatus (Boeck).
Euætideus giesbrechti Cleve (= *Ætideus mediterranea* Steuer).
**Ætideopsis multiserrata* Wolfend. (= *Chiridius nasutus* With).
Æ. rostratus Sars.
Undinopsis bradyi Sars (= *Bradyidius armatus* Giesbr.).
**U. similis* Sars (= *Bradyidius armatus* Vanhöffen).
Bradyetes inermis Farran.
Bryaxis brevicornis Farran.
**Chiridius armatus* (Boeck).
C. gracilis Farran.
**C. obtusifrons* Sars.
C. poppei Giesbr.
Chiridiella macrodactyla Sars.
C. brachydactyla Sars.
Gaidius affinis Sars.
G. brevicaudatus Sars.
**G. brevispinus* Sars (= *major* Wolfend.).
G. minutus Sars.
**G. tenuispinus* (Sars).
G. validus Farran.
Gætanus armiger Giesbr.
G. brachyurus Sars.
G. curvicornis Sars.
G. divergens Wolfend.
G. ferox With.

G. inermis Sars.
G. kruppi Giesbr. (= *major* Wolfend.).
G. latifrons Sars (= *holti* Farran, *longispinus* Wolfend.).
G. miles Giesbr.
G. minor Farran.
G. pileatus Farran.
G. robustus Jespersen.
G. rectus Wolf. (? = *brevicornis* Esterly, *hamatus* A. Scott).
Euchirella amœna Giesbr.
E. bitumida With.
E. brevis Sars.
E. curticauda Giesbr. (= *atlantica* Wolfend.).
E. gracilis Wolfend.
E. intermedia With.
E. maxima Wolfend.
E. messinensis (Claus).
E. pulchra (Lubb.).
E. rostrata (Claus) (= *Euchæta hessei* Brady).
E. spinosa Wolfend.
E. similis Wolfend.
Chirundina abyssalis With.
C. parvispina (Farran).
C. streetsi Giesbr.
Undeuchæta major Giesbr. (= *Chirundina angulata* Sars).
U. plumosa (Lubb.) (= *minor* Giesbr., *Euchæta australis* (Brady)).
Mesundeuchæta asymmetrica Wolfend.
Pseudochirella calcarata Sars.
P. cryptospina Sars (= *Gaidius parvispinus* Farran).
P. divaricata (Sars).
P. dubia Sars.
P. fallax Sars.
P. lobata Sars.
P. notacantha (Sars).
P. obtusa Sars (= *Chirundina abyssalis* With).
P. obesa Sars.
P. palliata Sars.
P. pustulifera (Sars) (= *Euchirella wolfendeni* Farran).
P. scopularis (Sars).
P. superba (With).
Valdiviella brevicornis Sars.
V. insignis Farran.
V. oligarthra Steuer.
Autanepsius major Wolfend.
Pseudeuchæta brevicauda Sars (= *Autanepsius minor* Wolfend.).
Euchæta hebes Giesbr.
E. rubicunda Farran.

E. spinosa Giesbr.
Paraeuchaeta barbata (Brady).
P. bisinuata Sars.
P. bradyi With.
**P. glacialis* (Hansen).
P. gracilis Sars (= *quadrata* (Farran)).
P. grandiremis (Giesbr.).
P. hanseni (With).
P. incisa (Sars).
**P. norvegica* (Boeck).
P. sarsi Farran.
P. scotti (Farran).
P. tonsa (Giesbr.).
P. tumidula (Sars).
Phaenna spinifera Claus.
Xanthocalanus claviger T. Scott.
X. echinatus Sars.
X. fallax Sars (= *borealis* Sars, 1903).
X. giesbrechti Thompson.
X. greeni Farran (= *calaminus* Wolfend.).
**X. hirtipes* Vanhöffen (= *borealis* Sars, 1900).
X. incertus Sars.
X. mixtus Sars.
X. muticus Sars.
X. obtusus Farran.
X. pinguis Farran.
X. profundus Sars.
X. sub-agilis Wolfend.
X. tenuiremis T. Scott.
X. tenuiserrata Wolfend.
Brachycalanus atlanticus (Wolfend.).
Amallophora typica T. Scott.
A. claviger T. Scott.
Heteramalla dubia Sars.
Onchocalanus affinis With.
O. cristatus (Wolfend.).
O. hirtipes Sars.
O. magnus Wolfend.
O. trigoniceps Sars (= *frigidus* Wolfend.).
Cornucalanus chelifer (Thomp.) (= *magnus* Wolfend.).
C. simplex (Wolfend.).
Undinella oblonga Sars.
U. simplex Wolfend (= *brevipes* Farran).
Cephalophanes refulgens Sars.
Oothrix bidentata Farran.
Scottocalanus helenae (Lubb.).

S. persecans (Giesbr.) (= *thori* With).
S. securifrons (T. Scott) (= *acutus* Sars).
Lophothrix frontalis Giesbr.
L. humilifrons Sars.
L. insignis Sars.
L. latipes T. Scott (= *Scolecithrix acuta* Wolfend.).
Scaphocalanus affinis Sars (? = *elongatus* A. Scott, ? *Amallophora gracilis* Wolfend.).
S. angulifrons Sars.
**S. brevicornis* (Sars) (= *gracilipes* Farran).
S. curtus Farran.
S. gracilis (Wolfend.).
S. echinatus Farran.
**S. magnus* (T. Scott) (= *acrocephalus* Sars).
S. medius Sars.
S. robustus T. Scott.
Amallothrix arcuata Sars.
A. curticauda (A. Scott).
A. emarginata Farran (= *obtusifrons* Sars).
A. gracilis (Sars) (? = *Scolecithrix globiceps* Farran).
A. laminata (Farran).
A. lobata Sars.
A. obtusifrons (T. Scott, *non* Sars) (= *Amallophora o.* T. Scott, *Scolecithricella tydemani* A. Scott).
A. propinqua Sars.
A. valens (Farran).
A. valida (Farran).
Scolecithrix atlanticus Wolfend.
S. fowleri Farran.
S. scotti Giesbr. (= *Amallophora dubia* T. Scott).
Neoscolecithrix kœhleri Canu (= *Oothrix bidentata* Farran).
Scolecithricella abyssalis (Giesbr.).
S. auropecten (Giesbr.).
S. dentata (Giesbr.).
S. ingolfi With.
S. minor (Brady).
S. ovata (Farran).
S. robusta (T. Scott).
S. tenuiserrata (Giesbr.).
S. vittata (Giesbr.).
Temorites brevis Sars.
Temoropia mayumbœnsis T. Scott.
Centropages typicus Kröyer
Metridia boecki Giesbr.
M. brevicauda Giesbr.
M. curticauda Giesbr.

**M. longa* (Lubb.).
M. lucens Boeck.
M. macrura Sars.
M. princeps Giesbr.
M. venusta Giesbr. (= *normani* Giesbr.).
Gaussia princeps (T. Scott).
Pleuromamma abdominalis (Lubb.).
P. borealis (Dahl).
P. gracilis (Claus).
P. piseki Farran.
P. robusta (Dahl).
P. xiphias (Giesbr.).
Lucicutia atlantica Wolfend. (= *magna* Wolfend., *gracilis* Sars).
L. challengeri Sewell (= *flavicornis* Brady, part).
L. bicornuta Wolfend. (= *aurita* Sars).
L. clausi (Giesbr.).
L. curta Farran.
L. flavicornis (Claus).
L. gemina Farran.
L. grandis (Giesbr.).
L. intermedia Sars.
L. longicornis (Giesbr.).
L. longiserrata (Giesbr.).
L. lucida Farran (= *pera* A. Scott).
L. macrocera Sars.
L. maxima Steuer.
L. ovalis Wolfend.
L. simulans Sars.
L. tenuicauda Sars.
Isochæta longisetosus.
I. ovalis Giesbr. (? = *Lucicutia frigida* Wolfend.).
Disseta palumboi Giesbr. (= *atlantica* Wolfend., *Heterorhabdus grandis* Wolfend.).
**Heterorhabdus abyssalis* (Giesbr.) (= *norvegicus* (Boeck)).
H. brevicornis (Dahl).
H. clausi (Giesbr.).
H. compactus Sars.
H. longicornis (Giesbr.).
H. norvegicus (Boeck) (= *profundus* Dahl).
H. papilliger (Claus).
H. robustus Farran (= *Alloiorhabdus austrinus* Wolfend.).
H. spinifrons (Claus).
H. tropicus Dahl.
H. vipera (Giesbr.).
Hemirhabdus grimaldii (Richard).
H. latus Sars.

Mesorhabdus angustus Sars.
M. brevicaudatus (Wolfend.) (= *annectens* Sars).
M. gracilis Sars.
Heterostylites longicornis (Giesbr.).
H. major (Dahl). (? = *longicornis* (Giesbr.)).
**Haloptilus acutifrons* (Giesbr.) (= *spinifrons* Sars).
H. angusticeps Sars.
H. bulliceps Farran.
H. chierchiæ (Giesbr.).
H. fertilis Giesbr.
H. fons Farran.
H. furcatus Sars.
H. longicornis (Claus).
H. mucronatus (Claus).
H. ornatus (Giesbr.).
H. oxycephalus (Giesbr.).
H. plumosus (Claus).
**H. spiniceps* (Giesbr.).
H. tenuis Farran.
H. validus Sars.
Pseudhaloptilus longimanus Wolfend.
Augaptilus anceps Farran.
A. cornutus Wolfend.
A. glacialis Sars (= *zetesius* Wolfend.).
A. longicaudatus (Claus).
A. megalurus Giesbr.
A. spinifrons Sars.
Euaugaptilus affinis Sars.
E. angustus Sars.
E. bullifer (Giesbr.).
E. clavatus (Sars).
E. digitatus Sars.
E. elongatus Sars.
E. facilis (Farran).
E. farrani Sars.
E. filigerus (Claus).
E. gibbus (Wolfend.).
E. gracilis Sars.
E. grandicornis Sars.
E. hecticus (Giesbr.).
E. humilis Farran.
E. latifrons (Sars).
E. laticeps (Sars) (= *antarcticus* Wolfend.).
E. longicirrhus (Sars).
E. longimanus Sars.
E. magnus (Wolf.) (= *fungiferus* Steuer).

E. maxillaris Sars.
E. nodifrons (Sars).
E. oblongus (Sars).
E. palumboi (Giesbr.).
E. penicillatus Sars.
E. propinquus Sars.
E. rigidus (Sars).
E. similis Farran.
E. squamatus (Giesbr.). (= *brevicaudatus* (Sars)).
E. tenuicaudus (Sars).
E. tenuispinus Sars.
E. truncatus (Sars).
E. vicinus Sars.
Centraugaptilus cucullatus (Sars).
C. horridus (Farran).
C. rattrayi (T. Scott).
Augaptilina scopifera Sars.
Pseudaugaptilina longiremis Sars.
Pontoptilus mucronatus Sars.
P. muticus Sars.
P. ovalis Sars.
P. pertenuis Sars.
P. robustus Sars.
Pachyptilus abbreviatus (Sars).
P. eurygnathus Sars.
P. lobatus Sars.
Heteroptilus acutilobus (Sars).
H. attenuatus (Sars).
Arietellus armatus Wolfend.
A. bispinatus.
A. giesbrechti Sars.
A. pavoninus Sars.
A. plumifer Sars.
A. setosus Giesbr.
A. simplex Sars.
Paraugaptilus buchani Wolfend.
P. meridionalis Wolfend.
Paramisophria cluthæ T. Scott.
Scottula abyssalis Sars.
Phyllopus æqualis Sars.
P. bidentatus Brady.
P. helgæ Farran.
P. impar Farran.
P. muticus Sars.
Bathypontia elegans Sars.
B. elongata Sars.

B. minor Sars.
Candacia armata Boeck.
C. elongata Boeck (= *rotundata* Wolfend., *obtusa* Sars).
C. falcifera Farran (? = *magna* Sewell).
C. longimana Claus.
**C. norvegica* Boeck.
C. tenuimana Giesbr. (= *gracilimana* Farran).
Labidocera wollastoni (Lubb.).
Anomalocera patersoni Templ.
Acartia clausi Giesbr.
Mormonilla phasma Giesbr.
M. minor Giesbr.
Oithona atlantica Farran (= *spinirostris* Sars).
O. setigera Dana (= *pelagica* Farran).
O. similis Claus.
Pontœciella abyssicola (T. Scott).
Paroithona parvula Farran.
Conœa rapax Giesbr.
Ratania atlantica Farran.
R. flava Giesbr.
Lubbockia brevis Farran.
Bathyidia remota Farran.
Microsetella norvegica Boeck.
M. rosea Dana.
Ægisthus aculeatus Giesbr.
Æ. dubius Sars.
Æ. mucronatus Giesbr.

Some of the above species have probably had their origin in the Arctic region and have been able to penetrate southwards into the North Atlantic and beyond ; these species I have indicated by an asterisk. A few others appear to have had their origin in the Southern Ocean, and are denizens of the West Wind Drift or of the true Antarctic region and have been carried northwards ; such species are *Drepanopsis frigidus* Wolfend., *D. pectinatus* Brady and *Metridia curticauda* Giesbr.

Russell (1935) has pointed out that a consideration of the general trend of the deep currents indicates that cold water species that have evolved from surface-living warm-water species will be carried southwards ; he gives figures, supplied by Farran, to show that out of 228 species belonging to 36 deep-sea genera only 3 have succeeded in reaching the Arctic and Boreal region. We have already seen that certain surface-living warm-water species may be swept northwards from the Gulf Stream in the North Atlantic Ocean into the Arctic region, and a few deep-sea species that appear to have had their origin in the North Atlantic seem to have been carried northwards by the North Atlantic Drift ; Lysholm and Nordgaard (1921, p. 35) give several such species that have reached as far as the coast of Norway and the Lofoten Islands, or even as far as lat. 70° N., namely :

Eucalanus elongatus (Dana),
Rhincalanus nasutus Giesbr.,
Ætideus armatus (Boeck),

Ætideopsis rostrata Sars,
Paraeuchæta farrani (With),
Haloptilus longicornis (Claus),

and With (1915, p. 166) considers that *Paraeuchæta norvegica* (Boeck) has been carried from the Atlantic to the Arctic Ocean and not *vice versa* ; and perhaps *Calanus finmarchicus* (Gunn.) has followed the same route.

But it seems clear that for the majority of those deep-sea species that have been evolved in the North Atlantic Ocean no such northward migration is possible. I have already called attention to the barrier that is presented to such migration by the Wyville-Thompson, the Faroe-Iceland and the Iceland-Greenland Ridges, and between these two last lies Iceland itself. Jespersen (1940, p. 102) has given tables showing the distribution round Iceland of the deep-sea Calanoida that have been captured in that region, and he shows that out of a total of 79 species, 54 are known only from the area to the south of the island and a further 17 only from the south and west areas. Along the north and east sides of the island 8 species have been captured, namely :

**Calanus hyperboreus* Kröyer.
**Spinocalanus abyssalis* Giesbr.
Ætideopsis rostratus Sars.
**Chiridius obtusifrons* Sars.
Euchirella rostrata (Claus).
**Paraeuchæta farrani* (With).
**P. glacialis* (Hansen).
**Scaphocalanus magnus* (T. Scott).

Of the above as many as 6 are in all probability Arctic forms (*vide supra*, p. 495) ; these I have indicated by an asterisk. Nearly all have been taken also on the south side of the island, the only exception to this being the species *Ætideopsis rostratus* Sars, which, however, is well known from the north Atlantic.

Directly connected with the Atlantic through the Strait of Gibraltar is the Mediterranean Sea, and this forms a separate zoological sub-region, since a number of species that are present in the Atlantic have not, as yet, been taken in the Mediterranean. This enclosed sea is at the present time separated from the North Atlantic below a depth of some 400 m. by the Gibraltar Ridge, and the work of Schott (1928) and others has shown that through this strait there is an inflowing current of surface water, while the deeper water flows out from the Mediterranean Sea into the Atlantic. Thus surface-living plankton can easily be carried from the Atlantic into the Mediterranean, whereas, on the other hand, deep-dwelling forms can be swept out of the Mediterranean Sea into the Atlantic Ocean, but cannot be carried in the reverse direction unless either the adults or, as seems more likely, their larval stages inhabit the upper stratum, or can at least survive in it for a sufficient length of time.

I give below a list of those deep-dwelling Calanoid Copepoda that have been recorded from the deeper water of the Mediterranean Sea :

**Calanus finmarchicus* (Gunn.).
C. helgolandicus (Claus).
**C. tenuicornis* Dana.
**Calanoides brevicornis* (Lubb.).

**Neocalanus gracilis* (Dana).
**Eucalanus attenuatus* (Dana).
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
Spinocalanus caudatus Sars.
S. heterocaudatus Rose.
**S. magnus* Wolfend.
Drepanopsis lyra Rose.
Monacilla typica Sars.
**Ætideus armatus* Brady.
**Eucætideus giesbrechti* (Cleve) (= *Ætideus mediterranea* Steuer).
Undinopsis bradyi Sars.
Pseudœtideus armatus (Boeck) (= *Chiridius armatus* Sars).
**Chiridius poppei* Giesbr.
**Gœtanus kruppi* Giesbr.
**Euchirella messinensis* (Claus).
**E. rostrata* (Claus).
Pseudochirella cryptospina Sars.
**P. obtusa* Sars.
**Euchœta hebes* Giesbr.
**E. spinosa* Giesbr.
**Phœnna spinifera* Claus.
Xanthocalanus agilis Giesbr.
X. minor Giesbr.
X. mixtus Sars.
Heteramalla dubia (T. Scott).
Onchocalanus cristatus Wolfend.
O. steueri Pesta.
O. trigoniceps Sars.
**Scaphocalanus magnus* (T. Scott).
Scolecithricella abyssalis (Giesbr.).
**S. dentata* (Giesbr.).
S. longipes (Giesbr.).
S. profunda (Giesbr.).
S. sub-vittata Rose.
**S. tenuiserrata* (Giesbr.).
S. vittata (Giesbr.).
**Amallothrix auropecten* Giesbr.
A. farrani Rose.
A. sarsi Rose.
Metridia lucens Boeck.
**Pleuromamma abdominalis* (Lubb.).
**P. borealis* (Dahl).
**P. gracilis* Claus.
**P. robustus* Dahl.
Lucicutia atlantica Wolfend.

*L. *clausi* Giesbr.
L. longiserrata (Giesbr.).
L. lucida Farran.
L. simulans Sars.
**Heterorhabdus papilliger* Claus.
**H. spinifrons* Claus.
**Haloptilus acutifrons* (Giesbr.).
H. angusticeps Sars.
H. fertilis (Giesbr.).
**H. longicornis* (Claus).
**H. mucronatus* (Claus).
**H. ornatus* (Giesbr.).
**H. oxycephalus* Giesbr.
H. plumosus (Claus).
H. spiniceps (Giesbr.).
H. tenuis Farran.
H. validus Sars.
Augaptilus anceps Farran.
**A. longicaudatus* (Claus).
**Euaugaptilus angustus* Sars.
**E. filigerus* (Claus).
**E. hecticus* (Giesbr.).
**E. laticeps* Sars.
**Arietellus setosus* Giesbr.

Of the above 74 species 10, namely—

Spinocalanus heterocaudatus Rose,
Drepanopsis lyra Rose,
Xanthocalanus minor Giesbr.,
X. mixtus Sars,
Onchocalanus steueri Pesta,
Scolecithricella longipes (Giesbr.),
S. sub-vittata Rose,
Amallothrix farrani Rose,
A. sarsi Rose.
Haloptilis fertilis (Giesbr.),

have so far not been recorded from any other area and are possibly endemic ; and Pesta has put forward the suggestion that *Euchæta hebes* Giesbr. originated in the Mediterranean Sea and has been carried thence into the Atlantic Ocean, in which it has been able to spread northwards to the English Channel. Wüst (1936) has concluded from the results obtained by the "Meteor" Expedition in the Atlantic Ocean that the outflowing water from the Mediterranean Sea forms the uppermost stratum of the North Atlantic intermediate water, and that this can be traced right across the North Atlantic in a southwesterly direction and then southwards along the Brazilian coast. Vallaux (1936) doubts whether the Mediterranean outflow is a continuous one, and likens it to "a series of globular

masses dispersed both in depth and expanse through the Atlantic, gradually merging with it at various distances, but not by any means extending to the limits of expansion given by Wüst." Iselin (1936) has, however, produced evidence that the effect of this outflow can be traced well into the region of the Sargasso Sea at a depth of 800–1200 m. Whether continuous or intermittent, this outflow must carry with it the fauna of the deeper water of the Mediterranean Sea, and thus can well account for the presence of Mediterranean species in the Atlantic Ocean, whence, as we shall see later, they can be dispersed to both Indian and Pacific Oceans.

The fact that no less than 40 species out of a total of 74, or 54 per cent., as indicated in the above list by asterisks, are known to be present in all three great oceans, Atlantic, Indian and Pacific, while 14 others, namely—

Calanus helgolandicus (Claus),
Spinocalanus caudatus Sars,
Monacilla typica Sars,
Xanthocalanus agilis Giesbr.,
Heteramalla dubia (T. Scott),
Onchocalanus cristatus Wolfend.,
Scolecithricella dentata (Giesbr.),
S. vittata (Giesbr.),
Lucicutia atlantica Wolfend.,
L. longiserrata (Giesbr.),
L. lucida Farran,
Haloptilus angusticeps Sars,
H. plumosus Claus,
H. spiniceps (Giesbr.),

are known from the Atlantic and Pacific Oceans, though they have not, as yet, been recorded from the Indian Ocean, might well be regarded as evidence in favour of the view that the Mediterranean Sea, being the last remaining portion of the older Tethys Sea, has in times past acted as a highway along which Indo-Pacific forms could be carried westward into the Atlantic Ocean, and that their presence to-day in this Mediterranean sub-region is due to their survival since early Tertiary times. I have, however, previously (*vide supra*, p. 473) pointed out that it has been suggested that during the Pleistocene Glacial epoch the Mediterranean Sea became completely cut off from the Atlantic, and during this period was reduced to two isolated inland lakes, such as the Caspian and Dead Seas are to-day ; such a change must have resulted in the extermination of its original marine fauna, and the present population must have been introduced subsequently to the melting of the ice and have come from the Atlantic Ocean. The supposition that the Mediterranean fauna originated, at any rate in part, from the Indo-Pacific region presupposes that these species originated in the Indo-Pacific area and spread westward, but I have already mentioned that the great majority of species that are to-day found in the deeper levels of the Atlantic Ocean appear to have had their origin in that region and, as we shall see later, the distribution of these species throughout the other great oceans indicates that migration has been from west to east, and not *vice versa*. The fact that, with the exception of the ten "endemic" species, all the others are known to occur in the Atlantic Ocean, is best

accounted for on the supposition that they are truly Atlantic species and have been swept eastward into the Mediterranean Sea on the one hand, and southward and then eastward into the Indian and Pacific Oceans on the other. If they have been carried into the Mediterranean Sea from the Atlantic they must have been living during some stage or other of their existence in the upper levels above 400 m. depth, and the fact that they have been able to survive in water that is known to have a uniform temperature of about 12·5° C., that being the temperature at all depths in the Mediterranean Sea below the level of the Strait of Gibraltar, would seem to indicate that they do possess this faculty. It is also well known that from time to time examples of deep-sea species are taken at or near the surface, and a study of the available records has shown that as many as 46 contained in the above list have been recorded from the upper levels of the Atlantic Ocean at less than 400 m. depth; and Rose (1925) has recorded 17 in the Mediterranean Sea in less than 210 m. depth. It would seem clear, therefore, that there is nothing inherently impossible or even improbable in the suggestion that the great majority of the deep-dwelling species in the Mediterranean Sea have been carried in from the Atlantic Ocean, and that this process may be going on at the present time.

As I have already mentioned (*vide supra*, p. 498), Wüst (1928, p. 522) has pointed out that the North Atlantic Intermediate Current is composed of water from three different sources. These distinct water masses must all contribute their share of plankton to the main stream. The main mass of the North Atlantic Intermediate water (*vide* Wüst, 1935, 1936) crosses the Equator on the west side of the ocean and passes southwards close to the Brazilian coast. In the southern hemisphere the current develops an easterly trend and tends to spread out; some of the water enters the Gulf of Guinea, though this movement appears to be more of the nature of a diffusion or of slow vortices than an actual current. Further south, between lats. 20°–30° S. a branch of this current flows across the whole width of the South Atlantic and past the Cape of Good Hope into the southern part of the Indian Ocean, where it has been detected at a depth of about 3000 m. (*vide* Clowes and Deacon, 1935). Finally, the remaining mass of the North Atlantic Intermediate water tends to rise towards the surface throughout the greater part of the Antarctic region that lies between the Weddell Sea eastwards as far as the longitude of the Cape of Good Hope. As Deacon (1937) has pointed out, there are certain localities in the Antarctic from which this deep warm water of the North Atlantic Intermediate Current is partly or wholly excluded by submarine ridges, as, for instance—

1. Vahsel Bay, south of the Weddell Sea.
2. Part of Ross Sea.
3. Bransfield Strait.

Probably there are many small basins, which possess similar conditions, near the Antarctic continent, and some even further north, such as Douglas Strait in the S. Sandwich Group and Moränen and Drygalski fjords in S. Georgia.

Brennecke (1921) supposed that the warm intermediate layer in the region of the Weddell Sea was formed by an outflow of water from the Indian Ocean towards the west, and this view was accepted by Drygalski (1926), who suggested that it was a part of the Agulhas Current, which presumably sank down and flowed westward to the Weddell Sea beneath the Sub-Antarctic Intermediate layer. Lohmann (1928) adopted this view

and used it to explain the presence of warm-water planktonic forms in the Weddell Sea region, and he was followed by Steuer (1933, p. 295), who pointed out that the plankton of the high seas can penetrate for considerable distances into the deeper layers and so can be carried about by the deep currents, so that cold-water forms are sometimes taken in the tropics and tropical forms occasionally make their appearance in the Antarctic. It is unfortunate that both these last authors based their explanation on the supposed existence of a deep current setting south-westward from the Indian Ocean, for it now seems reasonably certain that the intermediate water in the Weddell Sea area and considerably to the east of it is derived from the North Atlantic Intermediate Current.

Wolfenden (1908, p. 3) pointed out that a number of species have been taken in Antarctic and Sub-Antarctic waters that " belong undoubtedly to a sub-tropical or warm temperate area and are to be regarded as accidental " in this southerly region. Among such species he enumerates the following:

Surface-living Species.	Deep-dwelling Species.
Eucalanus subtenuis Giesbr.	*Ætideus armatus* Brady.
Euchæta marina (Prestand.).	*Undeuchæta major* Giesbr.
Centropages violaceus (Claus).	*Pleuromamma gracilis* (Claus).
Lucicutia flavicornis (Claus).	*Arietellus setosus* Giesbr.
Candacia sp.	
Labidocera acutifrons (Dana).	

The occurrence of such species on several occasions and in several different localities in the Antarctic region can, I think, hardly be regarded as " accidental." The general trend of the surface and deep currents, and the fact that where such currents impinge on one another there is a certain, and possibly a considerable, degree of admixture of the water, provides a perfectly rational explanation of the presence in southern latitudes of such warm-water surface species as are sufficiently hardy to withstand the change of temperature encountered in passing from one current to another, while deep-dwelling species can be transferred from one water mass to another, experiencing only a very small change in the temperature, salinity or oxygen-content of the water. Russell (1935, pp. 10–12) has called attention to the manner in which the deep currents of the Atlantic Ocean, and especially the movement of the North Atlantic Intermediate Current, must tend to carry species from the Arctic and North Temperate regions southwards into Sub-Antarctic and Antarctic waters, and he gives a list of species that, as a result of this, are found to be " bipolar epiplanktonic " in their distribution, namely :

Microcalanus pygmæus Sars.
Scaphocalanus magnus (T. Scott).
Metridia lucens Boeck.
M. longa (Lubb.).
Heterorhabdus compactus Sars.
Candacia falcifera Farran (? = *magna* Sewell).

Thanks to the work of Giesbrecht (1902), Wolfenden (1911), Farran (1929), Mackintosh (1934), Hardy and Gunther (1935) and Wilson (1938) we now have records of no less

than 96 Arctic or North Atlantic species that have been taken in Antarctic and Sub-Antarctic waters :

Calanus carinatus Kröyer (= *C. brevicornis* Lubb.).
**C. finmarchicus* (Gunn.).
**C. tenuicornis* Dana.
C. tonsus Brady.
**Neocalanus gracilis* (Dana).
**Calanoides brevicornis* (Lubb.).
Nannocalanus minor (Claus).
**Megacalanus princeps* Wolfend.
**Bathycalanus bradyi* (Wolfend.).
? **Eucalanus longiceps* Matthews (= *acus* Farran).†
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
Clausocalanus arcuicornis (Dana).
C. furcatus (Brady).
C. laticeps Farran.
Ctenocalanus vanus Giesbr.
Microcalanus pygmæus Sars.
Spinocalanus abyssalis Giesbr., represented by var. *pygmæus.*
S. horridus Wolfend. (? = *S. spinosus* Farran).‡
**S. magnus* (Wolfend.).
S. spinosus Farran.
**Euætideus giesbrechti* (Cleve).
**Ætideus armatus* Brady.
**Bradyidius armatus* Vanhöffen.
**Gaidius tenuispinus* (Sars).
**Pseudochirella notacantha* (Sars).
P. pustulifera (Sars) (= *Chirundina p ustulifera* Sars).
**Undeuchæta major* Giesbr.
**U. plumosa* (Lubb.) (= *minor* Giesbr.).
**Euchirella rostrata* (Claus).
Xanthocalanus tenuiserratus Wolfend.
Paraeuchæta farrani (With).
**P. scotti* (Farran).
**Onchocalanus magnus* Wolfend.
**O. trigoniceps* Sars (= *frigidus* Wolfend.).
O. cristatus Wolfend.
**Cornucalanus chelifer* (Thompson) (= *magnus* Wolfend.).
Scolecithrix römeri Mrazek.§

† In a previous paper (Sewell, 1929, p. 50) I have pointed out that I believe *Eucalanus acus* Farran to be a synonym of *E. longiceps* Matthews, and that the species recorded by With (1915, p. 52) from the North Atlantic under the title ? *Eucalanus attenuatus* (Dana) is the same form.

‡ *Spinocalanus horridus* Wolfend. is at present known only from the tropical Atlantic to the west of Cape Verde Islands ; *S. spinosus* Farran has been recorded from the west of Ireland and the Antarctic.

§ This species is according to Brady (1918, p. 23) synonymous with *Scolecithrix glacialis* Giesrb. from the Antarctic.

Scolecithricella minor (Brady).
S. ovata Farran.
S. robusta T. Scott.
**Amallothrix emarginata* Farran (= *obtusifrons* Sars).
**A. valida* Farran.
**Scaphocalanus affinis* Sars.
S. brevicornis (Sars).
S. echinatus (Farran).
**S. magnus* (T. Scott).
Temora turbinata (Dana).
**Metridia boecki* Giesbr.
**M. brevicauda* Giesbr.
**M. longa* (Lubb.).
**M. lucens* Boeck.
**M. princeps* Giesbr.
**Pleuromamma abdominalis* (Lubb.).
**P. borealis* (F. Dahl).
**P. gracilis* (Claus).
**P. robustus* (F. Dahl).
**P. xiphias* (Giesbr.).
Lucicutia atlantica (Wolfend.) (= *L. magna* Wolfend.).
**L. bicornuta* Wolfend. (= *L. aurita* Sars).
L. grandis (Giesbr.).
**Disseta palumboi* Giesbr.
Heterorhabdus robustus Farran (= *Alloiorhabdus austrinus* Wolfend.).
H. compactus Sars.
**Heterostylites longicornis* (Giesbr.).
**H. major* (F. Dahl).†
Haloptilus fons Farran.
**H. longicornis* (Claus).
**H. oxycephalus* (Giesbr.).
H. spiniceps (Giesbr.).
**Euaugaptilus laticeps* Sars.
**Augaptilus megalurus* Giesbr.
**Centraugaptilus rattrayi* T. Scott.
**Arietellus setosus* Giesbr.
**Phyllopus bidentatus* Brady.
P. helgæ Farran.
**Candacia falcifera* Farran (? = *magna* Sewell).
Acartia clausi Giesbr.
A. danæ Giesbr.
Mormonilla phasma Giesbr.
M. minor Giesbr.
Oithona plumifera Baird.

† As I have previously pointed out (Sewell, 1932, p. 303), I am of the opinion that *Heterostylites longicornis* and *H. major* are merely size groups of the same species.

O. similis Claus.
Oncæa conifera Giesbr.
O. mediterranea Giesbr.
O. notopus Giesbr.
Conæa rapax Giesbr.
Ratania atlantica Farran.
Corycæus (*Corycæus*) *speciosus* Dana.
C. (*Agetes*) *flaccus* Giesbr.
C. (*Urocorycæus*) *furcifer* Claus.
Sapphirina metallina Dana.
Ectinosoma melaniceps Boeck.
Microsetella norvegica (Boeck).
Macrosetella gracilis (Dana).
Clytemnestra rostrata Brady.

A number of these species are surface-living forms, and these may have reached the Sub-Antarctic and Antarctic regions by passing across the convergence zones (*vide supra*, p. 453 *et seq.*). The great majority, however, are deep-dwelling forms, and in all probability have been swept southwards in the North Atlantic Intermediate or bottom currents. In its deepest levels the Atlantic Ocean is known to be divided into two series of basins, eastern and western, that are separated from each other by the Mid-Atlantic Ridge, and Wüst (1938) has published a very interesting chart in which he shows the origin and distribution of the deep water in these two series of basins: he shows that the eastern series is filled with water that has its origin in the Arctic Ocean, whereas in the western series the water is in the main derived from the Antarctic, only a relatively small area in the western part of the North Atlantic being supplied with water from the Arctic region. The southward flow of Arctic bottom water along the eastern series of basins is finally stopped in the South Atlantic by the Walfisch Ridge, that connects the Mid-Atlantic Ridge with the African continent, but Wüst (1928) has shown that the last part of the southward flow of the North Atlantic Bottom Drift can be traced in the South Atlantic past the Rio Grande and Walfisch Ridges, and that it then turns sharply towards the surface, reaching a depth of some 800 m. in about lat. 56° S.

The same author has put forward the view that in the area of the Antarctic region lying between lats. 65°–69° S. and longs. 27°–45° W. there is a vertical " change over " of water, the surface water sinking down in the winter months and being replaced by up-welling water that is ultimately derived from the Atlantic Intermediate Current. Such an up-welling will carry with it examples of species that normally inhabit the warmer Atlantic current, and will bring them into cold Antarctic water that is carried northwards to reach the Sub-Antarctic convergence zone, where it sinks down and forms part of the Sub-Antarctic Intermediate Current. We thus should not be surprised to find that as many as 68 or 69 deep-sea species are common to the North Atlantic Ocean and the Sub-Antarctic region; and of these (48) indicated in the above list by an asterisk, are known from the Indian Ocean.

If these deep-sea species have been swept from the North Atlantic region to the Antarctic by the North Atlantic Intermediate Current, the main mass of which passes down the west side of the South Atlantic Ocean along the Brazilian coast, and only a small

offset or even merely a series of vortices carries this water across to the African side, we might still expect to find that some at least of these North Atlantic species were to be found in the Gulf of Guinea and the region to the south of it. T. Scott (1894) and others have recorded the following species from this area :

Calanus propinquus Brady.
C. tonsus Brady.
Neocalanus gracilis (Dana).
N. robustior (Giesbr.) [as ? *Calanus comptus* Dana].
Rhincalanus nasutus Giesbr.
Eucalanus attenuatus (Dana).
E. elongatus (Dana) [as *E. spinifer* T. Scott].
Ætideus armatus Brady.
Gætanus armiger Giesbr.
Gaidius similis (T. Scott) [as *Euchæta hessei* var. *similis*].
G. tenuispinus (Sars).
Euchirella pulchra Lubb.
E. messinensis (Claus).
Undeuchæta major Giesbr.
Valdiviella oligarthra Steuer.
Paraeuchæta valida (T. Scott) [as *Euchæta hebes* var. *valida* T. Scott].
Amallophora typica T. Scott.
Heteramalla dubia (T. Scott).
Phænna spinifera Claus.
Scolecithricella abyssalis Giesbr. [as *S. tumida* T. Scott].
S. ctenopus Giesbr.
S. dubia Giesbr.
S. longicornis T. Scott.
S. robusta T. Scott.
S. scotti Giesbr. [as *Amallophora dubia* T Scott].
S. similis T. Scott.
S. tenuipes T. Scott.
Lophothrix latipes (T. Scott).
Scaphocalanus magnus (T. Scott).
S. major (T. Scott).
Scottocalanus securifrons (T. Scott).
Pleuromamma abdominalis (Lubb).
P. gracilis (Claus).
Gaussia princeps (T. Scott).
Heterorhabdus spinifrons (Claus).
Euaugaptilus hecticus (Giesbr.).
Augaptilus longicaudatus (Claus).
Centraugaptilus rattrayi (T. Scott).
Haloptilus longicornis Claus.
H. mucronatus (Claus).
H. plumosus Claus.

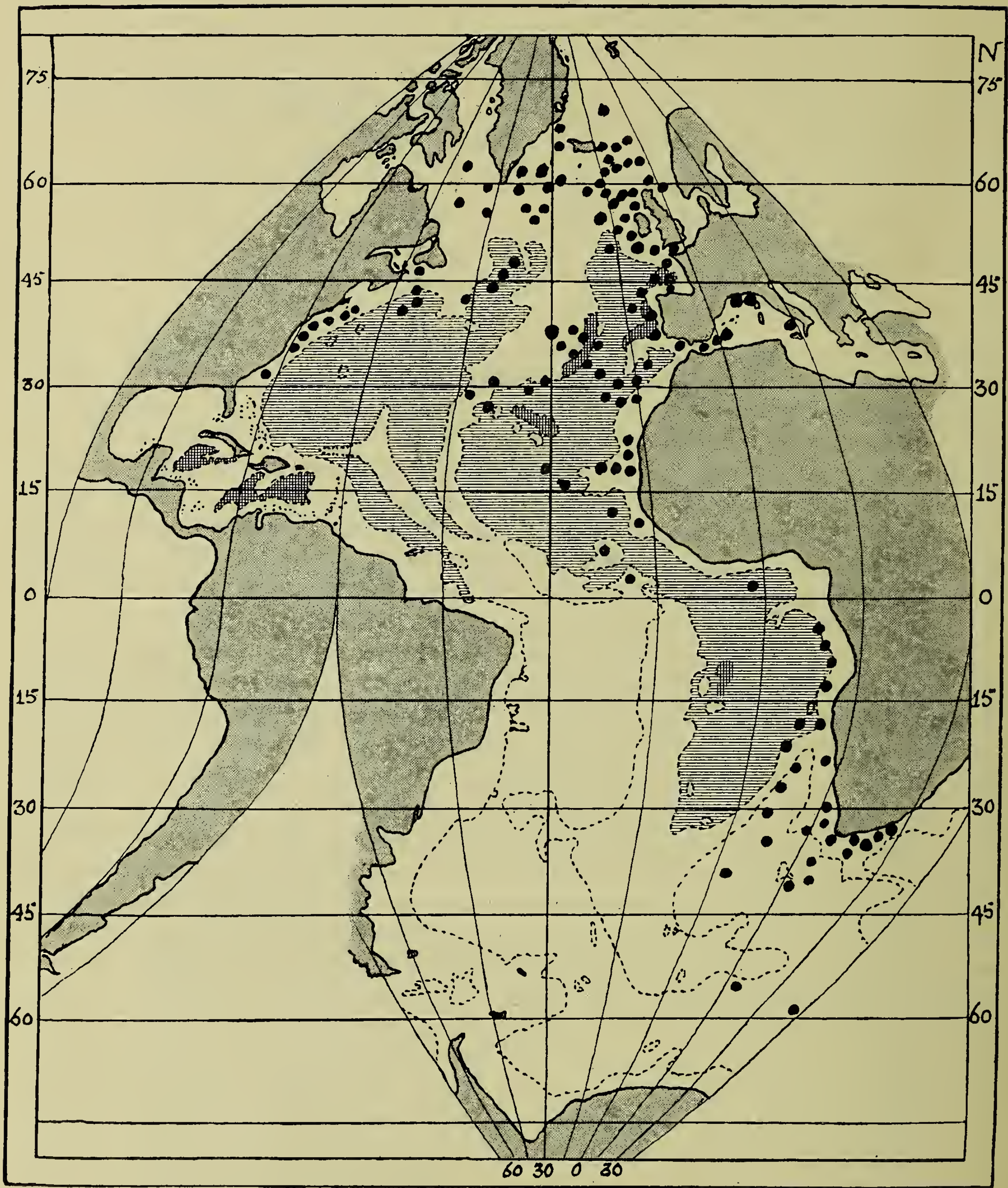
Arietellus setosus Giesbr. [as *Rhincalanus aculeatus* T. Scott].
Phyllopus bidentatus Brady.
Mormonilla phasma Giesbr.

An analysis of the above list reveals that out of the total of 44 species, three are known to be Arctic forms, namely, *Calanus tonsus* Brady, *Gaidius tenuispinus* (Sars) and *Scaphocalanus magnus* (T. Scott) ; one species. *Calanus propinquus* Brady, is usually regarded as an Antarctic form and five appear to be endemic, namely :

Paraeuchæta valida (T. Scott).
Scolecithricella scotti Giesbr.
S. similis (T. Scott).
S. robusta (T. Scott).
S. tenuipes (T. Scott).

All the others are known from other regions. In this connection it is interesting to note that certain species, that are usually taken in the North Atlantic in depths that correspond to the North Atlantic Intermediate Current, appear to have a distribution that much more closely approximates to the flow of the bottom water. This is especially clear in the case of *Rhincalanus nasutus* (Dana). In Text-fig. 89 I have given the general distribution of this Arctic bottom water, taken from Wüst (1938), and have superposed on it the distribution in the Atlantic of this species, taken, with a few additions, from the corresponding charts of Schmaus and Lehnhofer (1927) and Steuer (1931*b*) ; from this it appears that the actual distribution of this species agrees exactly with what one would expect were it due to the movement of the Arctic bottom water.

Wüst (1935, p. 141) states that the branch of the North Atlantic Intermediate Current that sets eastward in about lat. 40°–45° S., after passing to the south of the Cape of Good Hope and entering the Indian Ocean, is partly reflected by the Kerguelen-Gaussberg Ridge and then turns back and flows westward in the southern half of the Atlantic-Indian South Polar Basin as an undercurrent, which eventually reaches the Weddell Sea ; Sverdrup (1931), Schott (1933), Clowes and Deacon (1935) and Deacon (1937) are all of the opinion that a mass of Atlantic water, derived from the North Atlantic Intermediate Current, swings eastward past the Cape of Good Hope, and can be traced right across the southern part of the Indian Ocean and on into the south-west region of the Pacific. In the south-west region of the Indian Ocean, lying above this branch of the North Atlantic Intermediate Current, is a mass of water that is flowing northwards into the Indian Ocean, the Antarctic Intermediate Current. We should thus expect to find that either vertical migration from one water mass to the other, or actual admixture of these two masses of water along the boundary line between them, will transfer some at least of the North Atlantic species from the branch of the North Atlantic Intermediate Current to the Antarctic Intermediate Current, and that in consequence we shall find them in the tropical and sub-tropical regions of the Indian Ocean and the south-west Pacific Ocean, though, if Störmer (1933) be correct in his view that as we pass along a given current of water the number of species present at the outset steadily decreases, the actual numbers of North Atlantic species present should be greater in the Indian Ocean than in the Pacific region. Steuer (1933, p. 296) has already pointed out that the extension of the habitat of *Pleuromamma xiphias* (Giesbr.) into the equatorial region of the Indian Ocean in about 700 m. depth is due to the Antarctic Intermediate Current.



Text-fig. 89.—Showing the distribution of *Rhincalanus nasutus* Giesbr. and the flow of Arctic bottom water in the Atlantic Ocean. (After Wüst.)

Up to the present time comparatively little work has been carried out on the deep-dwelling Copepoda of the region round the Cape of Good Hope. Cleve (1904) and Stebbing (1910) have given the following species as inhabitants of this region; they were collected off the south-east coast of South Africa at depths ranging from 530–900 m.:

**Calanus finmarchicus* (Gunn.).
**C. tenuicornis* Dana.
Eucalanus attenuatus (Dana).
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
**Euætideus giesbrechti* (Cleve).
Gatanus armiger Giesbr.
G. miles Giesbr.
Chiridius poppei Giesbr.
Chirundina streetsi Giesbr.
**Undeuchæta major* Giesbr.
U. minor Giesbr. (= *plumosa* (Lubb.)).
Euchirella messinensis (Claus).
E. venusta Giesbr.
Paraeuchæta tonsa Giesbr.
P. affinis Cleve.
Scottocalanus persecans (Giesbr.).
S. securifrons (T. Scott).
Phænna spinifera Claus.
**Metridia brevicauda* Giesbr.
**M. princeps* Giesbr.
M. venusta Giesbr.
**Pleuromamma abdominalis* (Lubb.).
**P. gracilis* (Claus).
**P. robusta* (F. Dahl).
**P. xiphias* (Giesbr.).
Lucicutia aurita Cleve (non *L. aurita* Sars).
L. bradyana Cleve.
L. clausi Giesbr.
Heterorhabdus abyssalis Giesbr.
H. austrinus Giesbr.
H. papilliger (Claus).
H. spinifrons (Claus).
H. tanneri Giesbr.
Euaugaptilus palumboi Giesbr.
**Phyllopus bidentatus* Brady.

Cleve refers to these species as inhabitants of the Agulhas Current, but the depth from which they were taken seems to indicate that they were not inhabitants of this current but of the water layer lying immediately below it, namely, the Sub-Antarctic Intermediate Current. Out of a total of 36 species four have not been recorded from any area to the west of the Cape of Good Hope, namely, *Euchirella venusta* Giesbr., *Paraeuchæta affinis*

Cleve, *Lucicutia aurita* Cleve and *L. bradyana* Cleve ; one species, *Heterorhabdus austrinus* Giesbr., appears to be an Antarctic species that has been swept northwards, and *H. tanneri* Giesbr. is a Pacific form ; all the remaining 30 species are known from the North Atlantic Ocean, and of these 13 are among the North Atlantic forms that have been recorded from the Antarctic region ; these I have indicated by an asterisk in the above list. A further 14 species from the Cape region are common to both the Atlantic and Indian Oceans, but seem to have made their way from the one to the other by some route that does not entail penetration of the Sub-Antarctic region ; and this is almost certainly the Indo-Pacific branch of the North Atlantic Intermediate Current. In addition to the species of North Atlantic Copepoda that have been carried southwards into the Antarctic region, a number that are not sufficiently hardy to survive transference to the Sub-Antarctic area appear to have been swept eastward by the branch of the North Atlantic Intermediate Current into the south-western region of the Indian Ocean and then have been carried northwards, presumably in the Sub-Antarctic Intermediate water, so that they have been captured in the Arabian Sea or the Bay of Bengal to the west or east of India respectively. These species are as follows :

Calanoides patagoniensis Brady,
Neocalanus robustior (Giesbr.),
Bathycalanus richardi Sars,
Eucalanus attenuatus (Dana),
Monacilla tenera Sars,
Undinopsis bradyi Sars,
Chiridius gracilis Farran,
Gaidius minutus Sars,
Gætanus armiger Giesbr.,
G. curvicornis Sars,
G. kruppi Giesbr.,
G. latifrons Sars,
G. miles Giesbr.,
G. minor Farran,
G. pileatus Farran,
G. rectus Wolfend.,
Euchirella brevis Sars,
E. curticauda Giesbr.,
E. galeata Giesbr. (= *bitumida* With),
E. maxima Wolfend.,
E. messinensis (Claus),
E. pulchra (Lubb.),
E. truncata Esterly,
Chirundina streetsi Giesbr.,
Undeuchæta plumosa (Lubb.) (= *minor* Giesbr.),
Pseudeuchæta brevicauda Sars,
Pseudochirella cryptospina Sars,
P. notacantha Sars,
P. obtusa Sars,

Valdiviella brevicornis Sars,
V. insignis Farran,
V. minor Wolfend.,
V. oligarthra Steuer,
Euchæta spinosa Giesbr.,
? *Paraeuchæta barbata* (Brady),
P. bisinuata (Sars),
P. hanseni (With),
P. sarsi (Farran),
P. scotti (Farran),
P. tonsa (Giesbr.),
P. withi sp. nov.,
Phænna spinifera Claus,
Xanthocalanus greeni Farran,
Onchocalanus affinis With,
O. trigoniceps Sars,
Cornucalanus simplex Wolfend.,
C. chelifer (Thompson),
Scottocalanus helenæ (Lubb.),
S. persecans (Giesbr.),
S. securifrons (T. Scott),
Lophothrix frontalis Giesbr.,
L. humilifrons Sars,
L. quadrispinosa Wolfend.,
Scaphocalanus affinis Sars,
S. magnus (T. Scott),
S. medius Sars,
Scolecithricella tenuiserrata (Giesbr.),
Amallothrix arcuata Sars,
A. emarginata (Farran) (= *obtusifrons* Sars),
A. gracilis Sars,
Metridia curticauda Giesbr.,
M. macrura Sars,
M. princeps Giesbr.,
Pleuromamma indica Wolfend.,
P. quadrungulata (Dahl),
Gaussia princeps (T. Scott),
Lucicutia challengeri Sewell,
L. clausi Giesbr.,
L. maxima Steuer,
L. ovalis Wolfend.,
L. magna Wolfend.,
Heterorhabdus abyssalis (Giesbr.),
H. clausi (Giesbr.),
H. papilliger (Claus),
H. spinifrons (Claus),

H. vipera (Giesbr.),
Hemirhabdus grimaldii (Richard),
? *H. truncatus* (A. Scott) (? = *latus* Sars),
Euaugaptilus angustus Sars,
E. bullifer (Giesbr.),
E. digitatus Sars,
E. elongatus Sars,
E. facilis (Farran),
E. filigerus (Claus),
E. hecticus (Giesbr.),
E. grandicornis Sars,
E. latifrons Sars,
? *E. longicirrhus* Sars,
E. longimanus Sars,
E. magnus (Wolfend.),
E. nodifrons Sars,
E. oblongus Sars,
E. penicillatus Sars,
E. tenuispinus Sars,
Augaptilus longicaudatus (Claus),
Centraugaptilus horridus (Farran),
Haloptilus acutifrons (Giesbr.),
H. chierchiæ (Giesbr.),
H. mucronatus (Claus),
H. ornatus (Giesbr.),
H. oxycephalus (Giesbr.),
H. validus Sars,
Heteroptilus acutilobus Sars,
Pontoptilus ovalis Sars,
Arietellus giesbrechti Sars,
A. plumifer Sars,
A. simplex Sars,
Pachyptilus eurygnathus Sars,
P. lobatus Sars,
Phyllopus impar Farran,
P. muticus Sars,

and to these, in all probability, should be added the following Atlantic species that normally inhabit the upper stratum, but which appear to have been swept eastward occasionally from the Atlantic Ocean into the Indian Ocean by the branch of the North Atlantic Intermediate Current :

Calanus finmarchicus (Gunn.).
Ctenocalanus vanus Giesbr.
Euchæta hebes Giesbr.
Anomalocera patersoni Templ.
Labidocera nerii (Kröyer).

Pontella atlantica (M.E.).
P. mediterranea (Claus).
Parapontella brevicornis (Lubb.).
Centropages chierchiæ Giesbr.
C. typicus Kröyer.

A certain number of other species, which in spite of the extended researches that have been carried out in that area have not up to the present time been recorded from the North Atlantic Ocean, have been described by Wolfenden (1911) from the deeper levels of the ocean beneath the equator or in the South Atlantic Ocean. These species are as follows :

Mesogaidius maximus (? = *Gaidius validus* Farran),*
Gætanus brevicaudatus,
G. recticornis,
Pseudochirella magna (= *Chirundina magna*),
P. spinosa,
Chiridiella atlantica,
Mesundeuchæta asymmetrica,
Valdiviella minor,
Euchæta exigua (= *Paraeuchæta exigua*),
Onchocalanus subcristatus,
Scolecithrix æqualis,
S. magnus,
S. medius,
Amallophora elegans,
Lophothrix quadrispinosa,
L. similis,
L. simplex,
L. varicans,
Lucicutia major,
Hemirhabdus falciformis,
Euaugaptilus simplex (? = *E. nodifrons* Sars),*
E. subfiligerus,
Haloptilus major,
Arietellus minor,

and to this list we may add the following species :

Paraeuchæta valida (? = *P. barbata* (Brady)),*
Scolecithrix tumida (? = *S. abyssalis* Giesbr.),*
S. longicornis,
S. major (? = *Scaphocalanus medius* Sars),*
S. scotti Giesbr. (= *Amallophora dubia* T. Scott),
S. similis (= *Amallophora dubia* var. *similis*),
S. robusta (= *Amallophora robusta*),
Scolecithricella ctenopus (Giesbr.),
S. tenuipes,
Arietellus aculeatus (= *Rhincalanus aculeatus* T. Scott),

* If, as I believe, these species are synonymous, they are North Atlantic species, and their names should be added to the list on pp. 498–506.

which were recorded by T. Scott (1894) from the Gulf of Guinea. The majority of the above species were taken in the eastern part of the Atlantic Ocean from the equator southwards in hauls ranging from 1000 to 3000 m. depth, and reference to the charts of salinity in this section of the ocean given by Wüst (1935, Chart 27) shows that at these depths the species must have been inhabiting the North Atlantic Intermediate water ; but, as Wüst has shown, the main stream of this current runs down the west side of the Atlantic, off the coast of Brazil, and although some of this water finds its way across the South Atlantic to the west coast of Africa, this is brought about more by diffusion and vortices than as part of a direct stream. Furthermore, it is now well established that off the west and south-west coast of South Africa a mass of deep water wells up towards the surface, where it mixes with a branch of the West Wind Drift and with an offshoot from the Agulhas Current to form the Benguela Current, that runs first towards the north-west and then west across the Atlantic. Thus there seems to be little or no opportunity for species in this eastern part of the South Atlantic to get carried eastward into the Indian Ocean, and it is thus not surprising that out of the above 34 species, if we exclude those that are doubtful inhabitants of the North Atlantic, only 5 have been taken in the Indian Ocean or its offshoot, the Red Sea, namely :

Pseudochirella magna (Wolfend.),
Valdiviella minor Wolfend.,
Lophothrix quadrispinosa Wolfend.,
Scolecithricella ctenopus (Giesbr.),
S. tenuipes (T. Scott),

and only two are known from the Pacific Ocean—

Scolecithricella ctenopus (Giesbr.),
S. longicornis (T. Scott).

We thus have a grand total of some 165 species of deep-water Copepoda that have been recorded from both the Atlantic and the Indian Oceans, and whose presence in this latter area can be accounted for by transportation, first, along the branches of the North Atlantic Intermediate Current that flow either to the Sub-Antarctic region or past the Cape of Good Hope into the southern part of the Indian Ocean and on to the south-west area of the Pacific Ocean, and secondly, by the Sub-Antarctic Intermediate Current northwards to the Arabian Sea and the Bay of Bengal. In the case of the great majority of these species, they have been taken in the Indian Ocean in depths that seem to correspond to this water mass, but for a few species, such as *Paraeuchæta hanseni* With, *Valdiviella insignis* Farran and *Bathycalanus bradyi* Wolfend., which were taken in the Arabian Sea at depths of 2000 m. or over, it is probably the Antarctic Bottom Drift that is responsible for their northward transference.

The Indian Ocean, like the Atlantic, is divided into eastern and western regions by the Kerguelen-Gaussberg Ridge and its continuation northwards in the Carlsberg and Murray Ridges, the whole series forming the Mid-Indian Ridge ; both regions are composed of a series of basins (*vide* Wiseman and Sewell, 1937, and Sewell, 1937). Möller (1929) put forward the view that the Sub-Polar water sinks down in lats. 40°–60° S., and then flows northwards in the Indian Ocean at a depth of from 500 to 2000 m. to about lat.

20° S., after which it gradually thins out as it reaches the equator and finally disappears in about lat. 5° N.; but from the work of the "John Murray" expedition Mohamed (1940) has been able to show that this Sub-Polar water, which he terms the Antarctic Intermediate Current, can be clearly traced northwards into both the Gulf of Aden and the Gulf of Oman. We should expect to find that the effect of the Mid-Indian Ridge, combined with the effect of the earth's rotation, will tend to deflect the greater part of the Antarctic Intermediate water against the African coast; Mohamed (1940, p. 192), from his study of the pH distribution, reached the conclusion that "the Antarctic Intermediate Current enters the area of the north-western Indian Ocean mainly on the western side. It then tends to move north-eastward," and in the Arabian Sea it is divided into an upper and a lower stratum by the Indian Intermediate Current that is flowing southwards. The upper stratum divides into easterly and westerly branches, the latter moving towards the Gulf of Aden; the deeper stratum spreads widely at a depth of 2000 m. and reaches as far north as the Gulf of Oman. The Arabian basin is filled at a depth of 2000 m. with this Antarctic water. Steuer (1933) quotes Defant as saying that the Antarctic Intermediate Current does not penetrate into the Bay of Bengal, and to the absence of this water he attributes the absence in this area of the large cool-water form of *Pleuromamma xiphias* Giesbr. We have already seen that a number of North Atlantic species are carried southwards into the Antarctic and Sub-Antarctic region of the Atlantic Ocean, and if these be, as I have suggested, carried northwards again into the Indian Ocean in the Antarctic Intermediate Current, we should expect to find that their distribution in the Indian Ocean shows an agreement with the distribution of this cool water. Of the 96 North Atlantic species taken in the Antarctic, a full list of which is given above on p. 513, 46 have been taken in the Indian Ocean; of these, 19 species are common to both east and west regions of the Indian Ocean and have been taken on both sides of the Mid-Indian Ridge, namely:

Megacalanus princeps Wolfend.
Rhincalanus nasutus Giesbr.
Eucalanus elongatus (Dana).
Ætideus armatus Brady.
Undeuchæta major Giesbr.
Pseudochirella notacantha Sars.
Onchocalanus trigoniceps Sars.
Amallothrix emarginata (Farran).
Scaphocalanus magnus (T. Scott).
Metridia brevicauda Giesbr.
M. princeps Giesbr.
Pleuromamma abdominalis (Lubb.).
P. gracilis (Claus).
P. xiphias Giesbr.
Lucicutia bicornuta Wolfend.
Heterostylites longicornis (Giesbr.).
Disseta palumboi Giesbr.
Euaugaptilus laticeps Sars.
Candacia falcifera Farran (? = *magna* Sewell).

Eleven species have, so far, been recorded only in the western part of the Indian Ocean, that is, to the west of the Mid-Indian Ridge ; these species are :

Calanus finmarchicus (Gunn.).
Bathycalanus bradyi (Wolfend.).
Eucætideus giesbrechti (Cleve).
Bradyidius armatus Vanhöffen.
Euchirella rostrata (Claus).
Paraeuchæta scotti (Farran).
Onchocalanus affinis With (? = *magnus* Wolfend.).
Metridia longa (Lubb.).
Haloptilus longicornis (Claus).
H. oxycephalus (Giesbr.).
Phyllopus bidentatus Brady.

But we have already seen that the Antarctic Intermediate water fills the whole of the Arabian basin, which lies to the east of the Carlsberg Ridge, and if we include the whole of the Arabian Sea in the western area, the following additional species have been taken only in this western region of the Indian Ocean :

Eucalanus longiceps Matthews.
Gaidius tenuispinus (Sars).
Cornucalanus chelifer (Thompson).
Scaphocalanus affinis Sars.
Scolecithricella (*Amallothrix*) *valida* (Farran).
Augaptilus megalurus Giesbr.
Centraugaptilus rattrayi (T. Scott).
Arietellus setosus Giesbr.

Only three or four of these species have been taken in the eastern part of the North Indian Ocean, namely, in the Bay of Bengal, that have not been taken also in the western region ; these are :

Spinocalanus magnus Wolfend,
Lucicutia bicornuta Wolfend,
Metridia boecki Giesbr.,

and *Heterostylites major* (Dahl), if we regard this as a different species from *H. longicornis* (Giesbr.).

It thus appears that out of 96 species that have been swept southward from the North Atlantic into the Sub-Antarctic region, 42 have been able to reach the part of the Indian Ocean that lies to the north of the equator, but of these, 38 are at present known from the region to the west of India, namely, the Arabian Sea, and only 22 or 23 from the eastern region—the Bay of Bengal. Since the fauna of the Sub-Antarctic region is probably circumglobal in its distribution, we should expect to find that these North Atlantic deep-water species have also been taken in the Pacific Ocean, and this is the case regarding no less than 37 of the species that have been recorded from the Indian Ocean.

Exactly the same phenomenon can be seen in those other species that appear to have been swept directly eastward by the branch of the North Atlantic Intermediate Current

that runs past the Cape of Good Hope. Among these 111 species we have some 40 that have succeeded in reaching the Indian Ocean but have not, up to the present time, been taken further east in the Pacific Ocean. Of these 40 species, 5 have been taken in the Bay of Bengal, namely:

Bathycalanus richardi Sars.
Valdiviella minor Wolfend.
V. oligarthra Steuer.
Lophothrix quadrispinosa Wolfend.
Pleuromamma indica Wolfend.

Sixteen species have been taken in the Laccadive Sea, between India and Ceylon on the east and the Maldive-Laccadive Archipalagoes on the west:

Monacilla tenera Sars,
Gaidius minutus Sars,
Pseudochirella cryptospina Sars,
P. magna (Wolfend.),
P. notacantha Sars,
Valdiviella oligartha Steuer,
Onchocalanus trigoniceps Sars,
Lophothrix quadrispinosa Wolfend.,
Scolecithricella (*Amallothrix*) *arcuata* Sars,
Scaphocalanus affinis Sars,
Cornucalanus chelifer (Thompson),
Pleuromamma indica Wolfend.,
Mesorhabdus angustus Sars,
Euaugaptilus latifrons Sars,
E. tenuispinus Sars,
Pontoptilus ovalis Sars,

and to these should be added *Candacia norvegica* Boeck, that is represented by a variety *tropica* Sewell.

In contrast to this to the west of the Maldive-Laccadive Ridge, *i.e.* on the west side of the Mid-Indian Ridge and in the Arabian Sea Basin, we have records of the capture of no less than 25 species, namely:

Gætanus curvicornis Sars.
Pseudeuchæta brevicauda Sars.
Valdiviella oligarthra Steuer.
Paraeuchæta hanseni (With).
P. withi sp. nov.
Xanthocalanus greeni Farran.
Lophothrix quadrispinosa Wolfend.
Scolecithricella (*Amallothrix*) *arcuata* Sars.
Pleuromamma indica Wolfend.
Mesorhabdus angustus Sars.
Euaugaptilus digitatus Sars.

E. elongatus Sars.
E. grandicornis Sars.
E. latifrons Sars.
? *E. longicirrhus* Sars.
E. longimanus Sars.
E. penicillatus Sars.
E. tenuispinus Sars.
Haloptilus validus Sars.
Heteroptilus acutilobus Sars.
Arietellus giesbrechti Sars.
A. plumifer Sars.
Pachyptilus eurygnathus Sars.
P. lobatus Sars.
Phyllopus muticus Sars.

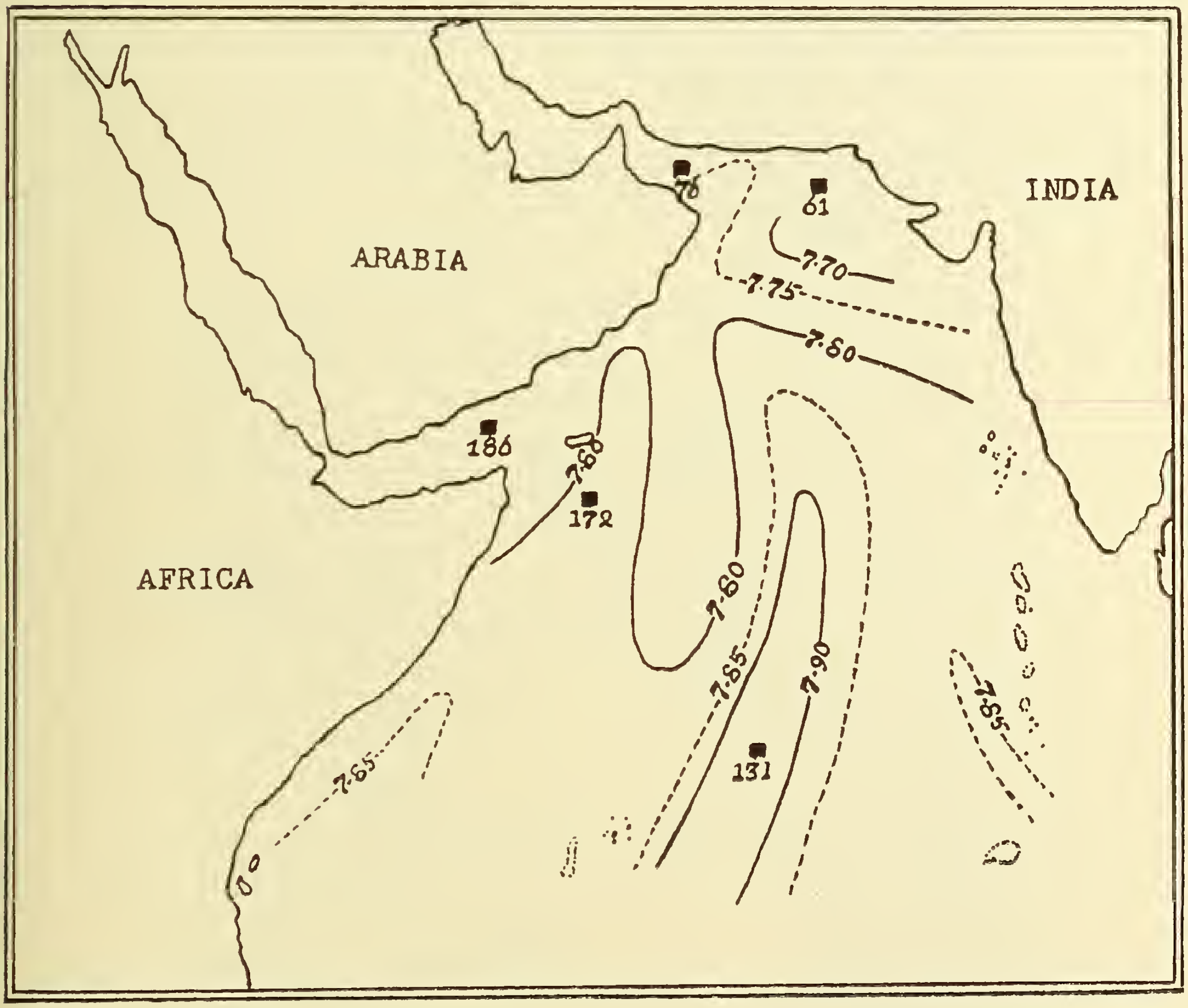
In the following table I have given the total number of North Atlantic species that have been taken in the three areas, from west to east, of the northern part of the Indian Ocean :

Area.	No. of Stations.	No. of N. Atlantic species.
West of Mid-Indian Ridge and Arabian Basin	6	92
Laccadive Sea	2	74
Bay of Bengal	4	41

It is extremely interesting to try and trace the distribution of the deep-dwelling Copepoda within the area investigated by the "John Murray" Expedition, and to correlate this with the different deep currents of water. Mohamed (1940) has shown that the Antarctic Intermediate water enters the north-western area of the Indian Ocean mainly on the western side ; he writes : "In the eastern regions of the area investigated this current lies below the North Indian deep current. In the central and western regions it is split up by the North Indian Deep Current into two portions, which we have designated as the upper and lower Antarctic Intermediate Currents ; in these regions the upper Antarctic Intermediate Current lies below the surface layer and above the North Indian Deep Current. Off the African coast the Antarctic Intermediate Current shows no splitting owing to the absence of the North Indian Deep Current. The horizontal distribution of the pH has shown that the Antarctic Intermediate Current enters the area of the north-western Indian Ocean mainly on the western side. It then tends to move north-eastward on account of the deflective forces of the earth's rotation, rising nearer to the surface on its way north. . . . The lower Antarctic Intermediate Current spreads widely at a depth of 2000 m. and reaches as far north as the Gulf of Oman." In the accompanying chart (Text-fig. 90) I have given the position of the various stations of the "John Murray" Expedition at which hauls of plankton were obtained and the pH distribution at a depth of 1500 m. At this depth we can clearly see the two branches of the Antarctic Intermediate Current, with a pH of 7.80 or over, moving northwards, and between them the North Indian Intermediate water, with a pH of less than 7.80, moving towards the south. Station 172 lies further to the north, but considerably further to the west than Sta. 131, and therefore, according to Mohamed, lies in the line of the main stream of Antarctic Inter-

mediate water. Hauls were obtained at this station from depths of 2091–0 m. and 850–0 m., and both of these must have sampled the Antarctic water. In these two hauls the following species were obtained :

**Calanoides patagoniensis* Brady.
**Megacalanus princeps* Wolfend.
**Eucalanus attenuatus* (Dana).
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
Gætanus brevicornis Esterly.
**G. kruppi* Giesbr.
**G. miles* Giesbr.
**G. minor* Farran.
**G. pileatus* Farran.
**Euchirella galeata* Giesbr.
E. orientalis Sewell.



TEXT-FIG. 90.—Showing thedisiibution of the Antarctic Intermediate Current at a depth of 1500 m., aud the portion of the " John Murray t'cions 61, 76, 131 and 172.rsn

**E. pulchra* (Lubb.).
Chirundina indica Sewell.
**C. streetsi* Giesbr.
Undeuchæta bispinosa Esterly.
**Valdiviella insignis* Farran.
**Euchæta spinosa* Giesbr.
E. tenuis Esterly.
**Paraeuchæta hanseni* (With).
P. investigatoris Sewell.
P. malayensis Sewell.
**P. sarsi* Farran.
P. spinifera Esterly.
**P. tonsa* Giesbr.
P. weberi A. Scott.
**Xanthocalanus greeni* Farran.
**Onchocalanus affinis* With.
**O. trigoniceps* Sars.
**Scottocalanus securifrons* (T. Scott).
**Scaphocalanus magnus* (T. Scott).
**Lophothrix frontalis* Giesbr.
**L. quadrispinosa* Wolfend.
**Scolecithricella (Amallothrix) arcuata* Sars.
**S. (A.) emarginata* (Farran).
**S. (A.) gracilis* Sars.
**Metridia princeps* Giesbr.
**Pleuromamma abdominalis* (Lubb.).
**P. indica* Wolfend.
**P. quadrungulata* (Dahl).
**Gaussia princeps* (T. Scott).
**Lucicutia challengeri* Sewell.
**Heterorhabdus abyssalis* (Giesbr.).
**H. spinifrons* (Claus).
**Hemirhabdus grimaldii* (Richard).
**H. truncatus* (A. Scott).
**Disseta palumboi* Giesbr.
**Haloptilus chierchiæ* (Giesbr.).
**H. ornatus* (Giesbr.).
**H. oxycephalus* (Giesbr.).
**H. validus* Sars.
**Euaugaptilus elongatus* Sars.
**E. facilis* (Farran).
E. indicus Sewell.
**E. laticeps* Sars.
**E. latifrons* Sars.
? **E. longicirrhus* Sars.
* *E. longimanus* Sars.

E. magnus (Wolfend.).
E. nodifrons Sars.
E. oblongus Sars.
**Augaptilus longicaudatus* (Claus).
**Arietellus simplex* Sars.
**Pachyptilus eurygnathus* Sars.

Of these 64 species, as many as 54, or 84 per cent., are known to occur in the Atlantic Ocean; these are marked with an asterisk. At the same Station, but at a somewhat higher level in two hauls from 400–0 and 200–0 m., six deep-sea species were taken, namely:

Eucalanus pseudattenuatus sp. nov.
Euchirella bella Giesbr. var. *indica* Wolfend.
**E. truncata* Esterly.
Scottocalanus dauglishi Sewell.
**Pleuromamma quadrungulata* (Dahl).
**Arietellus giesbrechti* Sars.

Of these, three, marked by an asterisk, are known from the Atlantic Ocean, so that it would appear that at this depth there is a considerable admixture of Antarctic Intermediate water with the surface stratum, and to this admixture is to be attributed the presence of the three Atlantic species.

At Sta. 131 the two hauls, from 2000–0 m. and 1500–0 m. respectively, will have sampled the deep layer of Antarctic Intermediate water, and the Copepoda taken in these hauls were:

**Neocalanus gracilis* (Dana).
**N. rubustior* (Giesbr.).
**Megacalanus princeps* Wolfend.
**Eucalanus attenuatus* (Dana).
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
Gætanus brevicornis Esterly.
**G. kruppi* Giesbr.
**G. pileatus* Farran.
Euchirella bella Giesbr. var. *indica* Wolfend.
**E. galeata* Giesbr.
**E. maxima* Wolfend.
**E. pulchra* (Lubb.).
**E. truncata* Esterly.
E. venusta Giesbr.
Chirundina indica Sewell.
**C. streetsi* Giesbr.
**Pseudochirella obtusa* Sars.
Undeuchæta bispinosa Esterly.
**U. major* Giesbr.
Euchæta tenuis Esterly.
Paraeuchæta malayensis Sewell.

**P. sarsi* Farran.
**P. scotti* (Farran).
**P. tonsa* Giesbr.
P. weberi A. Scott.
**P. withi* sp. nov.
**Scottocalanus persecans* (Giesbr.).
**S. securifrons* (T. Scott).
**Scaphocalanus magnus* (T. Scott).
**Lophothrix frontalis* Giesbr.
**Metridia princeps* Giesbr.
**Pleuromamma abdominalis* (Lubb.).
**P. quadrungulata* (Dahl).
**P. xiphias* (Giesbr.).
**Lucicutia bicornuta* Wolfend.
**Heterostylites longicornis* (Giesbr.).
**Heterorhabdus abyssalis* (Giesbr.).
**Hemirhabdus grimaldii* (Richard).
**Disseta palumboi* Giesbr.
**Euaugaptilus bullifer* (Giesbr.).
**E. nodifrons* Sars.
**Haloptilus mucronatus* (Claus).
**H. ornatus* (Giesbr.).
**H. oxycephalus* (Giesbr.).
**Arietellus giesbrechti* Sars.

At this station out of a total of 46 species, 38, or 82·5 per cent., are known from the Atlantic Ocean ; I have again indicated these species by an asterisk.

If, as I suggest, these Atlantic species have been swept eastwards in the Atlantic intermediate water and then northwards in the Antarctic Intermediate Current, and if Störmer (1933) be correct in his view that the number of species originally present in any given current of water will steadily decrease as we pass down the current away from its source, then we should expect to find that as we go northwards from Sta. 131 the number of Atlantic species will diminish. At Sta. 61 at the entrance to the Gulf of Oman the Antarctic Intermediate water forms a very clear layer between the depth of 1500 m. and the bottom ; at this station two hauls were taken from 2000–0 m. and 1500–0 m., and it seems safe to assume that these hauls will have sampled the Antarctic Intermediate Current. The following deep-sea species were obtained :

**Calanus finmarchicus* (Gunn.).
**Eucalanus elongatus* (Dana).
E. pseudattenuatus sp. nov.
**Rhincalanus nasutus* Giesbr.
Gætanus antarcticus Wolfend.
**G. curvicornis* Sars.
Euchirella bella Giesbr.
**E. maxima* Wolfend.
**Pseudochirella notacantha* Sars.
**Pseudeuchæta brevicauda* Sars.

**Valdiviella oligarthra* Steuer.
**Paraeuchaeta bisinuata* Sars.
**Lophothrix humilifrons* Sars.
Scolecithricella (*Amallothrix*) *indica* Sewell
**Metridia princeps* Giesbr.
**Lucicutia challengeri* Sewell.
**Heterostylites longicornis* (Giesbr.).
**Hemirhabdus truncatus* (A. Scott).
**Mesorhabdus angustus* Sars.
**Haloptilus chierchiae* (Giesbr.).
**Euaugaptilus angustus* Sars.
**E. digitatus* Sars.
**E. elongatus* Sars.
**E. grandicornis* Sars.
**E. laticeps* Sars.
**E. latifrons* Sars.
**E. longimanus* Sars.
**E. magnus* (Wolfend.).
**E. nodifrons* Sars.
**E. oblongus* Sars.
**E. penicillatus* Sars.
**E. tenuispinus* Sars.
**Centraugaptilus horridus* (Farran).
**Pachyptilus eurygnathus* Sars.
**P. lobatus* Sars.
**Phyllopus muticus* Sars.

At this station we thus get only 36 deep-sea species, and of these, 32, marked with an asterisk, or 89 per cent., are known to occur in the Atlantic Ocean, and one species, *Gaetanus antarcticus*, comes from the Antarctic Ocean, where Wolfenden obtained it.

Proceeding westwards still further into the Gulf, at Sta. 76 near the head of the Gulf of Oman the Antarctic Intermediate water occupies the deeper levels below about 1500 m., and in the haul from this depth to the surface we get the following species :

**Calanoides patagoniensis* Brady,
**Eucalanus elongatus* (Dana),
Euchirella bella Giesbr.,
**Onchocalanus affinis* With,
**Scaphocalanus magnus* (T. Scott),
**Metridia princeps* Giesbr.,
**Pleuromamma indica* Wolfend.,
**Lucicutia challengeri* Sewell,
**Haloptilus chierchiae* (Giesbr.),
**Euaugaptilus longimanus* Sars,
**E. nodifrons* Sars,
**Centraugaptilus horridus* (Farran),
**Phyllopus impar* Farran,
**Pachyptilus eurygnathus* Sars,

and from the stratum above this depth in a haul from 600–0 m. we obtained the following additional species:

***Eucalanus attenuatus* (Dana).
***Euchirella maxima* Wolfend.
***Mesorhabdus angustus* Sars.
***Disseta palumboi* Giesbr.
***Haloptilus acutifrons* (Giesbr.).

Of these 19 species, 18, marked with an asterisk, are known from the Atlantic Ocean, the only exception being *Euchirella bella*, which is known from the Cape of Good Hope region. At the same station from a haul between 2500–0 m. two other species were obtained, namely *Bathycalanus bradyi* (Wolfend.) and *Gætanus antarcticus* Wolfend.; both of these species have been recorded by Wolfenden from the Antarctic region, but the former is also known from the North Atlantic.

Mohamed (1940, p. 192) has put forward the view that the upper stratum of Antarctic Intermediate water divides off the entrance to the Gulf of Aden into two branches, the western of which swings into and passes up the Gulf. If this be so, we should expect to find that at Sta. 186 in the Gulf of Aden most, at any rate, of the species present have also been taken at Stas. 131 and 172 in the Antarctic Intermediate water. The collection at this station was made in the month of May, and Mohamed has shown that at this time of the year there is a mass of water entering the Gulf at a depth of about 200 m., which appears to be Antarctic Intermediate water; below this lies a stratum, extending between 600–1000 m., which is probably outflowing Red Sea water, and finally on the bottom is a second stratum of inflowing oceanic water, which must almost certainly be Antarctic Intermediate water. Unfortunately the depths at which the deep hauls were made at this station fall either within or very near the upper limit of the outflowing Red Sea water. Even so, one might expect to find that the majority of the species taken here would prove to be the same as those taken at Stas. 131 and 172. The species recorded from this station are as follows:

***Eucalanus attenuatus* (Dana).
***E. elongatus* (Dana).
***Rhincalanus nasutus* Giesbr.
***Gætanus kruppi* Giesbr.
***Euchirella galeata* Giesbr.
***E. maxima* Wolfend.
E. orientalis Sewell.
***E. pulchra* (Lubb.).
Chirundina indica Sewell.
Undeuchæta bispinosa Esterly.
Euchæta tenuis Esterly.
Paraeuchæta investigatoris Sewell
P. weberi A. Scott.
Scottocalanus daughlishi Sewell
***Lophothrix frontalis* Giesbr.
***Pleuromamma xiphias* (Giesbr.).
***Heterorhabdus spinifrons* (Claus).
***Euaugaptilus magnus* (Wolfend.).
***Heteroptilus acutilobus* Sars

All these were obtained from depths of 575 m., 600 m. and 960 m. At a higher level in a haul from 250–0 m. examples were taken of *Euchirella bella* Giesbr. We thus have in this area 20 deep-sea species, of which 12, marked with an asterisk, are known to be Atlantic species, and the remaining 8 appear to have had their origin in the Indian Ocean or off the Cape of Good Hope.

It is thus clear that as we pass northwards along the Antarctic Intermediate Current there is, as Störmer anticipated, a gradual falling off in the number of deep-sea Copepoda, and especially of North Atlantic species ; this is seen very clearly in the following table :

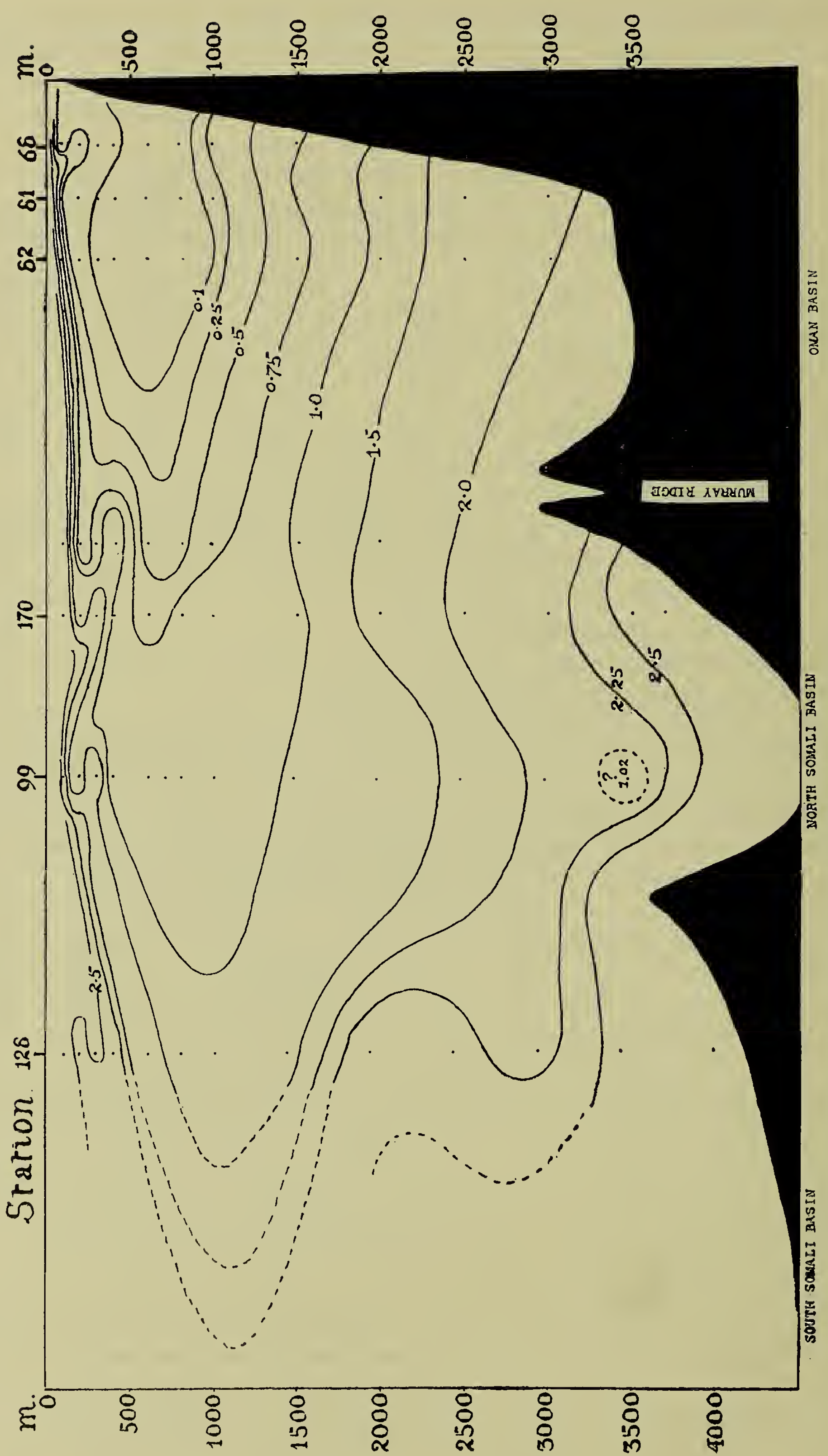
Station.	172.	131.	61.	76.	186.
North Atlantic species	56	38	32	19	12
Indian species	14	8	3	1	8
Total	70	46	35	20	20

A further point that seems to be indicated is that those species that have not been taken further to the west than in Indian waters, and are presumably indigenous, appear to have difficulty in getting into the Gulf of Oman, three species only having been carried as far as the entrance to the Gulf, namely :

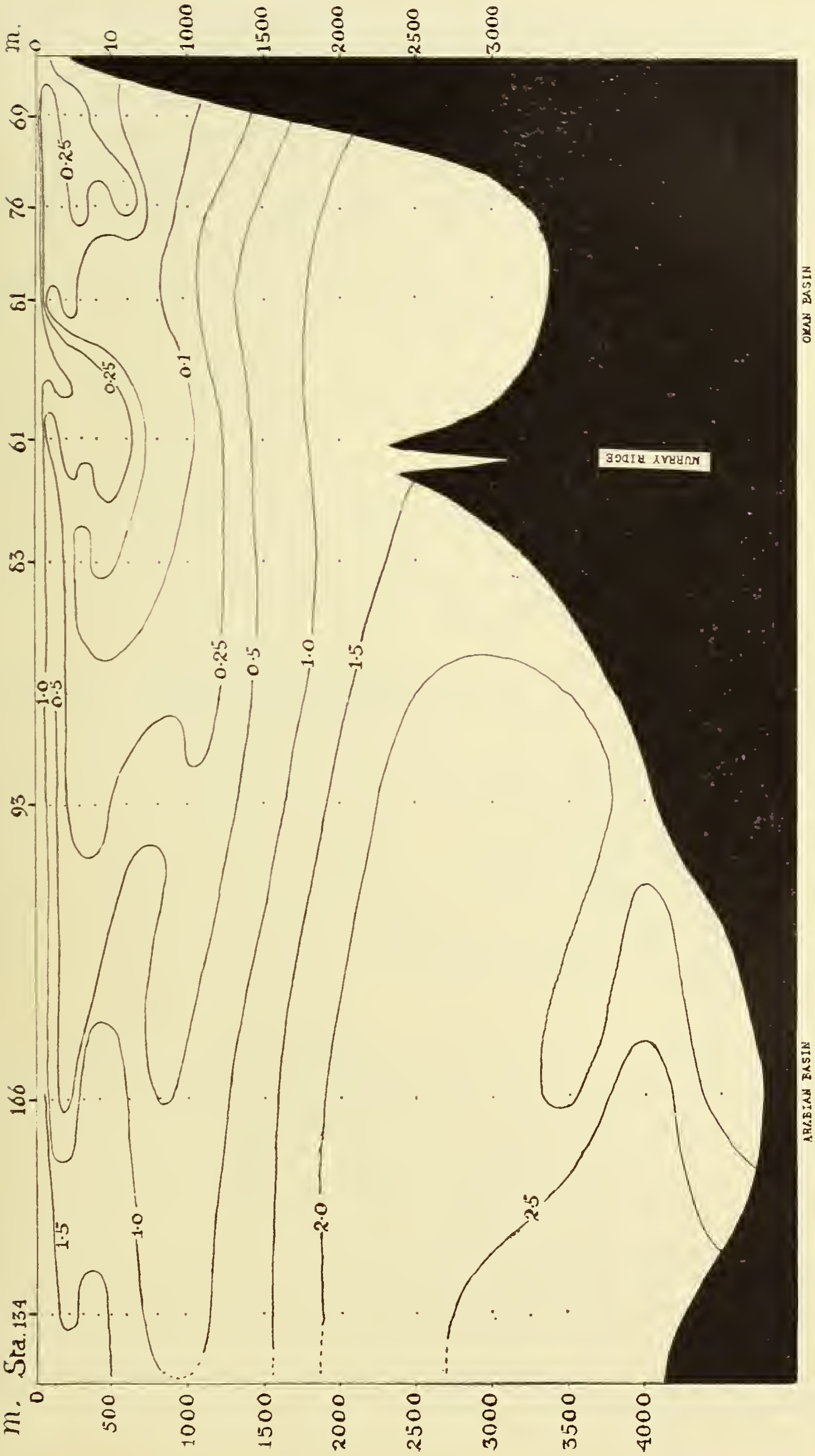
Eucalanus pseudattenuatus sp. nov.,
Euchirella bella Giesbr.,
Scolecithricella (*Amallothrix*) *indica* Sewell,

and of these only the second, *Euchirella bella* Giesbr., has reached the head of the Gulf.

The Indian Intermediate Current has its origin along the coast of Arabia and in the Gulf of Oman, and this mass of water is characterized by a low pH concentration and an extremely low oxygen-content. Mohamed (1940, p. 191) has pointed out that this mass of water " off the South Arabian and Indian coasts . . . lies immediately below the surface layer, but further west it is separated from it by the upper Antarctic Intermediate Current ; off the African coast it is practically non-existent. . . . This current, which exhibits a three-fold division in the upper levels, tends to move south-westwards on account of the deviating force of the earth's rotation and . . . sinks to greater depths on its way south until it reaches its greatest expanse at a depth of 800 m." The course taken by this current is very clearly shown in the chart of oxygen distribution (Text-figs. 91 and 92) ; at Stas. 68, 76, 81 and 82 in the Gulf of Oman this water lies immediately beneath the surface and extends down to a depth of about 1000 m., the oxygen content of the water being less than 0·1 c.c. per litre. As we trace the current southwards through Stas. 170, 99 and 128 in the series of basins on the west side of the Mid-Indian Ridge (Text-fig. 91), the current of North Indian Intermediate water can be seen extending southwards at a depth of about 1000 m., and at the same time the oxygen content steadily rises till at Sta. 128 (lat. 5° 31′ 42″ S.) in the main axis of the current this has risen to nearly 1·5 c.c. per litre. In the section through the eastern series of basins (Text-fig. 92), the North Indian Intermediate water is seen equally clearly to be passing southwards, the main mass of the current lying at about 1000 m. depth, but in this section the rise of oxygen content is not so rapid, for at Sta. 134 (lat. 2° 55′ 30″ N.) the value is



Text-fig. 91.—Showing the distribution of O_2 content in a section down the western side of the Arabian Sea.



TEXT-FIG. 92.—Showing the distribution of the O_2 content in a section down the east side of the Arabian Sea.

still under 1·0 c.c. per litre. As the main mass of the current lies at a depth too great for the growth and activity of chlorophyll-bearing phyto-plankton, and in the southern part of the eastern section is clearly separated from the surface water by the upper layer of Antarctic Intermediate water, this rise of oxygen must be attributed to admixture with the water masses immediately above and below, *i.e.* with the Antarctic Intermediate water, accompanied by diffusion of the gas from one water mass to the other. At its origin the North Indian Intermediate water corresponds to the area of sea-bottom to which I have previously (Sewell, 1934) referred and which is characterized by a complete absence of life.

The deep-sea species of Copepoda that were taken at Sta. 76 at the head of the Gulf of Oman in a haul from 600–0 m. are as follows :

Calanoides patagoniensis Brady.
Eucalanus attenuatus (Dana).
E. elongatus (Dana).
Rhincalanus nasutus Giesbr.
Euchirella maxima Wolfend.
Mesorhabdus angustus Sars.
Disseta palumboi Giesbr.
Haloptilus acutifrons Giesbr.

At Sta. 61, near the entrance to the Gulf, a haul from 1000–0 m. yielded only the following species :

Eucalanus elongatus (Dana).
Rhincalanus nasutus Giesbr.
Euchirella bella Giesbr.
Lucicutia challengeri Sewell.
Euaugaptilus latifrons Sars.
E. nodifrons Sars.
Centraugaptilus horridus (Farran).
Pachyptilus eurygnathus Sars.

Combining these two results, we have present at a depth that corresponds to the North Indian Intermediate water as few as 14 deep-sea species, of which 13 are Atlantic forms, and only a single species, *Euchirella bella*, is an Indian form. This paucity of life is in marked contrast to the richness of the surface stratum, in which as many as 70 species were present, and the deeper stratum below 1500 m., in which 38 species were taken at Sta. 61 and 16 species at Sta. 76. Moreover, with the exception of *Eucalanus attenuatus* (Dana) and *Disseta palumboi* Giesbr., all the species that were taken in the North Indian water are also present in the deeper water of the Antarctic Intermediate Current. It seems justifiable to conclude that at its origin the North Indian Intermediate water, like the sea floor, is for all practical purposes devoid of life, so far as the Copepoda are concerned, and that the few species present have been carried in from the deeper and richer Antarctic water by diffusion or turbulence.

Outside the Oman basin at Sta. 96 in the Arabian Basin a haul was taken with the

self-closing net between 645 and 400 m., in the middle of the main mass of North Indian Intermediate water; here the following species were obtained:

**Megacalanus princeps* Wolfend.
**Eucalanus attenuatus* (Dana).
**E. elongatus* (Dana).
E. pseudattenuatus sp. nov.
**Rhincalanus nasutus* Giesbr.
**Gætanus kruppi* Giesbr.
**G. miles* Giesbr.
**G. pileatus* Farran.
Euchirella bella Giesbr.
**E. galeata* Giesbr.
E. orientalis Sewell.
Chirundina indica Sewell.
**C. streetsi* Giesbr.
**Pseudochirella magna* (Wolfend.).
Undeuchæta bispinosa Esterly.
Euchæta tenuis Esterly.
Paraeuchæta investigatoris Sewell.
**P. tonsa* Giesbr.
P. weberi A. Scott.
**Onchocalanus trigoniceps* Sars.
Scottocalanus dauglishi Sewell.
**Scaphocalanus magnus* (T. Scott).
**Lophothrix frontalis* Giesbr.
Amallothrix indica Sewell.
**Metridia princeps* Giesbr.
**Pleuromamma xiphias* (Giesbr.).
**Lucicutia challengeri* Sewell.
**Heterorhabdus abyssalis* (Giesbr.).
**H. spinifrons* (Claus).
**Disseta palumboi* Giesbr.
**Haloptilus validus* Sars.
**Euaugaptilus nodifrons* Sars.
**E. magnus* (Wolfend.).
**Arietellus plumifer* Sars.
**A. simplex* Sars.

The total number of deep-sea species has now increased to 35, and of these, 25 are Atlantic forms and are marked with an asterisk. No less than 23 of these 25 Atlantic forms have been recorded from the Antarctic Intermediate water at Sta. 172 and 16 from Sta. 131. It thus seems justifiable to conclude that this increase in the number of species as we pass away from the source of this North Indian Intermediate water is, like the increase in the amount of dissolved oxygen, due to admixture with the Antarctic Intermediate water.

I have already drawn attention to the fact that in these Indian waters we find a number of species that have not, up to the present time, been taken in the Atlantic Ocean, in spite of the great amount of work that has been carried out there ; I believe that these species have originated in the Indian Ocean itself. The full list of these species is as follows :

†*Calanoides natalis* Brady,
†*Bradycalanus gigas* sp. nov.,
?*B. typicus* A. Scott,
†*Eucalanus pseudattenuatus* sp. nov.,
Undinopsis tropicus Wolfend. (? = *Bradyidius armatus* (Brady)),
†*Chirundina indica* Sewell,
Gætanus brevicornis Esterly,
Euchirella bella Giesbr.,
†*E. orientalis* Sewell,
E. venustus Giesbr.,
Undeuchæta bispinosa Esterly,
†*Valdiviella ignota* Sewell,
†*Euchæta arabica* Sciacchitano,
E. tenuis Esterly,
Paraeuchæta gracillicauda A. Scott,
†*P. investigatoris* Sewell,
P. malayensis Sewell,
P. spinifera Esterly,
P. tuberculata A. Scott,
P. weberi A. Scott,
†*Cornucalanus indicus* Sewell,
†*Xanthocalanus gigas* Sciacchitano,
†*Scottocalanus dauglishi* Sewell,
S. farrani A. Scott,
†*S. investigatoris* Sewell,
S. thomasi A. Scott,
Scaphocalanus elongatus A. Scott,
†*Amallothrix indica* Sewell,
†*Amallophora coistata* Sciacchitano,
†*Lucicutia aurita* Cleve,
†*L. bradyana* Cleve,
†*Euaugaptilus indicus* Sewell,

and perhaps to these may be added *Heterorhabdus tanneri* Giesbr. ; but this last species may have originated in the water of the West Wind Drift (*vide infra* p. 570). Several of these species, marked in the above list with a dagger, have not, up to the present time, been recorded from any other region, and it is possible that they are endemic.

Euchæta arabica Sciacchitano, *Amallophora coistata* Sciacchitano and *Xanthocalanus gigas* Sciacchitano have only been recorded from the Gulf of Aden. *Lucicutia aurita* Cleve and *L. bradyana* Cleve are at present known only from the Cape of Good Hope region, and *Calanoides natalis* Brady from the coast of Natal. *Bradycalanus gigas* sp. nov. and *Eucalanus pseudattenuatus* sp. nov. have so far been taken only in the

Arabian Sea, *Chirundina indica* Sewell and *Amallothrix indica* Sewell in the Arabian Sea and Laccadive Sea. *Scottocalanus dauglishi* Sewell and *Euaugaptilus indicus* Sewell in the Arabian Sea, Laccadive Sea and Bay of Bengal, and *Euchirella orientalis* Sewell and *Paraeuchæta investigatoris* Sewell in the Arabian Sea and the Bay of Bengal, but so far not in the Laccadive Sea; *Scottocalanus investigatoris* Sewell* has been taken in the Laccadive Sea only and *Valdiviella ignota* Sewell and *Cornucalanus indicus* Sewell in the Bay of Bengal only. It would thus appear that the main centre of production of these Indian species lies on the west side of the Indian Ocean or in the Arabian Sea, and, in addition, the local conditions that are present in this region appear to be responsible for the evolution of small or depauperized forms of certain other species, such as the "dwarf" race of *Pleuromamma xiphias* (Giesbr.) that is found in the western part of the Arabian Sea and the Gulf of Aden (*vide* Steuer, 1932, p. 70). In the Gulf of Oman we captured only one Indian species, namely, *Euchirella bella* Giesbr., but as we follow the North Indian intermediate water southwards the number of Indian species that were taken greatly increases. At Sta. 96 in a haul with the self-closing net between 645 and 400 m., which must have sampled the North Indian water, we obtained no less than 10 species, namely:

Eucalanus pseudattenuatus sp. nov.
Euchirella bella Giesbr.
E. orientalis Sewell.
Chirundina indica Sewell.
Undeuchæta bispinosa Esterly.
Euchæta tenuis Esterly.
Paraeuchæta investigatoris Sewell.
P. weberi A. Scott.
Scottocalanus dauglishi Sewell.
Amallothrix indica Sewell.

Still further south at Sta. 131 in a haul from 1500–0 m., which again must have sampled the North Indian Intermediate water, we obtained 8 Indian species, namely:

Euchirella bella Giesbr.
E. venusta Giesbr.
Chirundina indica Sewell.
Undeuchæta bispinosa Esterly.
Euchæta tenuis Esterly.
Paraeuchæta malayensis Sewell.
P. weberi A. Scott.
Gætanus brevicornis Esterly.

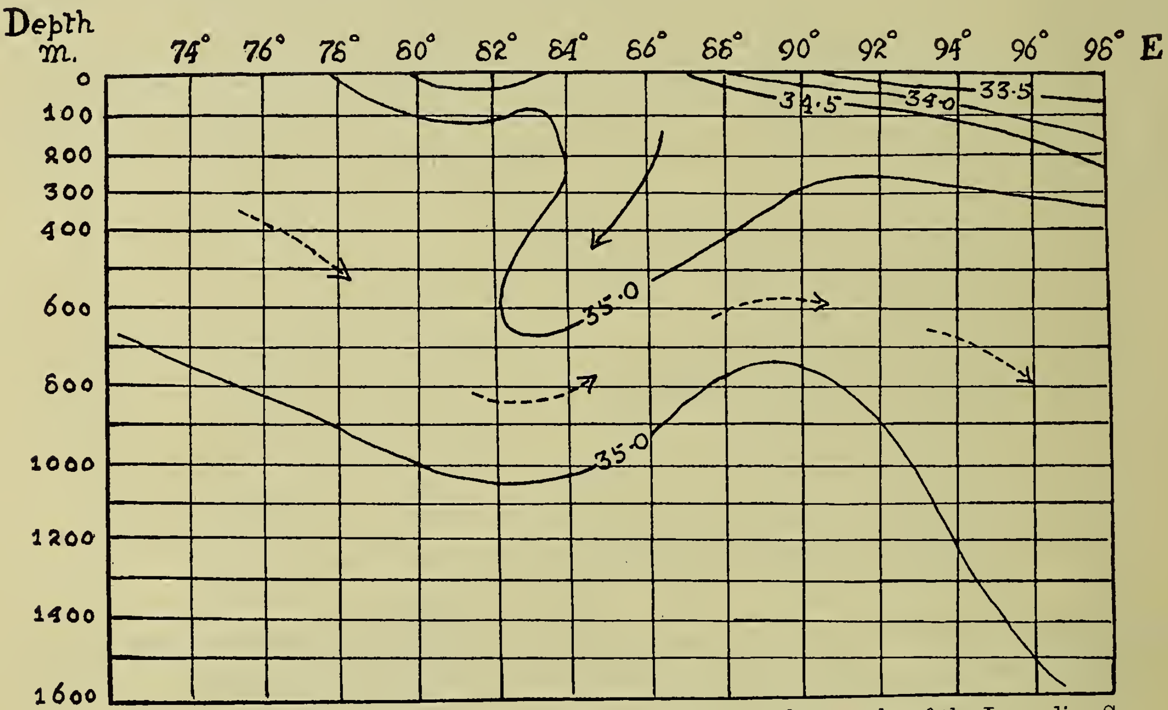
It appears probable that, although there is some difficulty in the way of the dispersal of these Arabian Sea species eastward into the Laccadive Sea and the Bay of Bengal, some at any rate have been able to find their way there. Between the Arabian Sea and the Laccadive Sea to a point just south of the equator lies the barrier of the Laccadive and Maldive Archipelagoes, but moderately deep channels run between the various atolls.

* Farran (1936, p. 101) has described *Scottacalanus australis* ♀ from the Great Barrier Reef and suggested the possiblity that this is the female of *S. investigatoris* Sewell, that is known only from the male.

One of these is Kardiva Channel, in which, at Sta. 145, we carried out a series of observations ; here we obtained 6 Indian species, namely :

Euchirella bella Giesbr.
E. orientalis Sewell.
Chirundina indica Sewell.
Undeuchæta bispinosa Esterly.
Euchæta tenuis Esterly.
Scottocalanus dauglishi Sewell.

The stratum from which these species were taken at this station was the upper 500 m. In a previous paper (Sewell, 1932*b*, p. 374), I have pointed out that a study of the isohalines



Text-fig. 93.—Showing the isohalines from West to East across the mouths of the Laccadive Sea and Bay of Bengal between Latitudes 1° and 10° N. (From Sewell, 1932.)

from west to east across the Laccadive Sea and Bay of Bengal suggests that between lats. 1° to 10° N. there is a mass of water, probably a part of the Contra-equatorial Current, that at its western side extends downwards from the surface to about 600 m., and that this is flowing eastward across the mouth of the Laccadive Sea and past Ceylon, till off the south-east corner of this island this current becomes split into two streams by a current flowing out of the Bay of Bengal at a depth of some 600 m. ; the upper branch passes into the Bay of Bengal, and the lower continues eastward and gradually sinks till, in lat. 96° E., it extends from 350 m. down to about 1500 m. (*vide* Text-fig. 93), and it was from this mass of water that the Indian species mentioned above were taken in the Laccadive Sea in a depth of 366 m. and in the Bay of Bengal in 766 m.

The ultimate distribution of these Indian species of planktonic Copepoda will be dependent on the course of the North Indian Intermediate Current. Most of the hydrographic work that has been carried out in the Indian Ocean has been concerned with the

region lying to the west of the Mid-Indian Ridge, and there is a considerable divergence of opinion regarding the distance to the south of the equator to which this current can be traced. Thomsen (1933) concluded that the mass of the North Indian Intermediate water, with a salinity of more than 34·80‰. did not extend beyond a line drawn from the north end of Madagascar to Ceylon. Clowes and Deacon (1935) trace it as far as lat. 20° S. in the Mozambique Channel at a depth of about 1500 m. where it meets the eastward current of North Atlantic Intermediate water, but they are of the opinion that the Indian Intermediate water flows much further southwards, sandwiched between the Atlantic water and the Antarctic Intermediate water. and Deacon (1937, p. 97) suggests that the volume and salinity of the North Indian Intermediate Current are subject to large variations, possibly related to current differences brought about by the changes of the monsoon winds and variations in the south equatorial current. If this Indian water reaches as far south as this on the west side of the Indian Ocean south of the equator, where the strength of the current is least, it can, I think, safely be assumed that in the eastern part of the ocean the current will be greater and extend further southward. One source of origin of this Indian Intermediate water lies at the head of the Arabian Sea, and the outflow from the Arabian Basin is, as we have seen, pushed away from the African coast by the northwardly flowing Antarctic Intermediate water: at the same time it seems likely that the configuration of the ocean floor will also tend to displace the Indian water eastward in much the same manner as the Mid-Atlantic Ridge deflects the Arctic water into the eastern series of basins (*vide supra*, Text-fig. 89, p. 518). It is also probable that at least at certain seasons of the year the mass of North Indian Intermediate water flowing out of the Arabian Sea is augmented by an outflow of water from the Andaman Sea and Bay of Bengal (*vide* Sewell, 1932). Deacon (1937, p. 97), however, doubts the existence of this latter source ; he states that "the observations made by the 'Snellius' and 'Dana' also show that no deep current comparable with that which flows from the Arabian Sea and its adjoining gulfs is formed in the north-eastern part of the ocean (Möller, 1933, p. 234), and the salinity distribution in the cross section from west to east across the ocean in 8 N. to 2 S. shows that the deep water formed in the western part of the ocean spreads towards the east." The mass of water of the North Indian Intermediate Current will, under the influence of the earth's rotation, have imparted to it an easterly trend that will carry it to the south of Australia and then, as Möller (1929) has suggested, eastward into the Pacific Ocean.

The south-western region of the Pacific Ocean appears to be filled in its deeper levels with water that has several different sources of origin well outside the geographical limits of the ocean itself. Both Sverdrup (1931) and Schott (1935) are of the opinion that the water of the South Pacific Ocean at a depth of 1500 m. is an importation from the depths of the Indian Ocean, and even further westward from the Atlantic Ocean. Deacon (1937, p. 98) has summarized our knowledge up to the time of his report, and he shows that there are indications in the south-eastern part of the Indian Ocean of a mass of water that is derived partly from the Indian Intermediate Current that is moving towards the south-east and is becoming mixed with the Antarctic bottom water and partly from the eastward continuation of the current of North Atlantic water that, as we have seen, swings eastward from the South Atlantic past the Cape of Good Hope and on across the southern part of the Indian Ocean. Deacon (*loc. cit.*, p. 101) has also pointed out that as we pass eastward from the region to the south of Australia into the Pacific Ocean, "the bottom

topography south of New Zealand is so irregular that the eastward current must be interrupted by numerous eddy movements, which will cause the salinity to be lowered by turbulent mixing with the less saline waters in the shallower and deeper strata" ; and such mixing of the water masses must be accompanied by an equal mixing of the plankton. The south-west region of the Pacific Ocean has undergone, and, according to the most recent investigations, is still undergoing great orographical changes. Umbgrove (1938) remarks : "We conclude from the occurrence of bathyal and abyssal sediments among mesozoic rocks of many an island that, during the Mesozoic, deep-sea basins must have existed within the bounds of the present Archipelago. . . . The marine sediments we know from the Tertiary of the entire Archipelago are littoral and neritic rocks, deposited in a shallow sea. . . . Even in the areas where a very intensive Miocene folding took place the facies of the sediments shows that the bottom was never situated at a great depth below the level of the sea. From these facts alone it is evident that the present deep-sea relief of the East Indian Archipelago is a characteristic that must have originated during the recent geological past." Kuenen (1935) places the most important part of the movement in the Pleistocene. He remarks (*loc. cit.*, p. 50) : "The general conclusion, therefore, is that the deep-sea troughs and geanticlines date from the end of the Tertiary and are still in course of further development." If this view be correct, it seems clear that these deep-sea basins must have become populated by their planktonic fauna in equally recent times.

As in the other two oceans, we have in the Pacific beneath the West Wind Drift, in about lat. 40° S., a mass of water that sinks down and turns northwards, where it forms the South Polar or Antarctic Intermediate layer, lying, according to Defant (1930), between 1000 and 1500 m. This Antarctic Intermediate water on the east side of New Zealand can be traced as far as 0°–16° N., but the strength of the current seems to increase as we pass eastwards first to the central part of the ocean and then to the south-east region (*vide* Deacon, 1937, p. 69). The work of the "Snellius" expedition (*vide* van Riel, 1934, 1938) has, however, shown that certain basins in the Malay Archipelago, namely, the Beroe, Banda, Wettar and Sawoe basins, seem to be filled with water that has flowed in from the east at a depth of less than 1500 m. (*vide* Text-fig. 73, p. 337). In consequence this area must be included in the Pacific region, and not, as I previously have done (Sewell, 1929, 1932), in the Indian Ocean.

If the plankton has been transported along all these various currents into the Pacific we should be able to find evidence of the contribution that each has made. Thanks to the work of Brady (1899), Cleve (1901), A. Scott (1909), Früchtl (1924), Farran (1925 and 1936), Wilson (1942) and Vervoort (1946) we now possess an extensive knowledge of the Copepod fauna of the south-western area, and I have been able to collate records of some 200 deep-sea species, of which the Atlantic Ocean appears to have contributed as many as 154, namely :

†*Calanus finmarchicus* (Gunn.).
? *C. helgolandicus* (Claus).
†*C. tenuicornis* Dana.
C. tonsus Brady.
Calanoides brevicornis (Lubb.) (= *C. carinatus* (Kröyer)).
†*Neocalanus gracilis* (Dana).

†*N. robustior* (Giesbr.).
†*Megacalanus princeps* Wolfend.
†*Bathycalanus bradyi* Wolfend.
†*B. richardi* Sars.
†*Ctenocalanus vanus* Giesbr.
†*Eucalanus attenuatus* (Dana).
†*E. elongatus* (Dana).
†*E. longiceps* Matthews (= *acus* Farran).
†*Rhincalanus nasutus* Giesbr.
Spinocalanus abyssalis Giesbr.
S. hirtus Sars.
†*S. magnus* Wolfend. (=*Latifrons* Sars).
S. spinosus Farran. (=*Norridus* Wolf.).
S. validus Sars.
Mimocalanus cultrifer Farran.
Monacilla typica Sars. (=*dubia* A. Scott).
†*Euætideus giesbrechti* (Cleve).
†*Ætideus armatus* (Boeck).
Æ. bradyi A. Scott.
Ætideopsis multiserrata (Wolfend.) (= *rostrata*, A. Scott, *non* Sars).
†*Bradyidius armatus* (Vanhöffen) (= *Undinopsis similis* Sars).
†*Chiridius poppei* Giesbr.
†*C. gracilis* Farran.
†*Chirundina streetsi* Giesbr.
Pseudotharybdis zetlandicus T. Scott.
†*Gætanus armiger* Giesbr.
†*G. kruppi* Giesbr.
†*G. latifrons* Sars.
†*G. miles* Giesbr.
†*G. minor* Farran.
†*G. pileatus* Farran.
†*G. rectus* Wolfend. (= *brevicornis* Esterly and *hamatus* A. Scott).
Gaidius affinis Sars.
G. notacanthus Sars.
†*G. tenuispinus* Sars (= *similis* T. Scott).
Euchirella amœna Giesbr.
†*E. brevis* Sars.
†*E. curticauda* Giesbr.
†*E. galeata* Giesbr.
†*E. maxima* Wolfend.
†*E. messinensis* (Claus).
†*E. pulchra* (Lubb.).
†*E. rostrata* (Claus).
†*Undeuchæta major* Giesbr.
†*U. plumosa* (Lubb.) (= *minora* Sars).
†*Pseudochirella obtusa* Sars (= *abyssalis* With, *dubia* A. Scott).

†*Valdiviella brevicornis* Sars.
†*V. insignis* Farran.
Euchæta pubera Sars.
†*E. spinosa* Giesbr.
?†*Paraeuchæta barbata* Brady.
†*P. bisinuata* Sars.
†*P. sarsi* Farran.
†*P. tonsa* Giesbr.
Chiridiella macrodactyla Sars.
†*Phænna spinifera* Claus.
Xanthocalanus agilis Giesbr.
†*Onchocalanus affinis* With (= *hirtipes* Sars).
O. cristatus (Wolfend.).
†*Cornucalanus simplex* Wolfend.
Amallophora typica T. Scott.
Heteramalla dubia (T. Scott).
†*Scottocalanus helenae* (Lubb.).
†*S. persecans* (Giesbr.).
†*S. securifrons* (T. Scott).
†*Lophothrix frontalis* Giesbr.
L. latipes (T. Scott) (= *Scolecithrix acuta* (Wolfend.)).
Scaphocalanus curtus (Farran).
S. echinatus (Farran).
†*S. magnus* (T. Scott).
S. major (T. Scott).
†*S. medius* Sars (= *gracilipes* Farran, ? *major* (T. Scott)).
†*Scolecithricella abyssalis* (Giesbr.).
†*S. auropecten* (Giesbr.).
†*S. ctenopus* (Giesbr.).
S. dentata (Giesbr.).
S. longicornis (T. Scott).
S. ovata (Farran).
S. profunda (Giesbr.).
†*S. tenuipes* (T. Scott).
†*S. tenuiserrata* (Giesbr.).
S. vittata (Giesbr.).
Amallothrix curticauda (A. Scott).
†*A. emarginata* (Farran).
†*A. gracilis* (Sars).
A. obtusifrons Sars (? = *Scolecithricella tydemani* A. Scott).
†*A. valida* (Farran).
Temoropia mayumbæensis T. Scott.
†*Metridia bœcki* Giesbr.
†*M. brevicauda* Giesbr.
M. lucens Boeck.
†*M. macrura* Sars.

†*M. princeps* Giesbr.
†*M. venusta* Giesbr.
†*Pleuromamma abdominalis* (Lubb.).
†*P. gracilis* (Claus).
†*P. borealis* (Dahl).
P. piseki Farran (= *gracilis* (Claus)).
†*P. robusta* (F. Dahl).
†*P. xiphias* (Giesbr.).
†*Lucicutia atlantica* Wolfend. (= *gracilis* Sars).
L. bicornuta Wolfend.
†*L. challengeri* Sewell.
†*L. clausi* (Giesbr.).
L. gemina Farran.
L. longiserrata (Giesbr.).
†*L. lucida* Farran (= *pera* A. Scott).
†*L. maxima* Steuer.
†*L. ovalis* Wolfend.
†*Candacia falcifera* Farran (? = *magna* Sewell).
†*Heterorhabdus abyssalis* (Giesbr.) (? = *norvegicus* (Boeck)).
†*H. clausi* (Giesbr.).
H. norvegicus (Boeck).
†*H. papilliger* (Claus).
†*H. spinifrons* (Claus).
†*Heterostylites longicornis* (Giesbr.).
†*Hemirhabdus grimaldii* (Richard).
†*H. truncatus* (A. Scott) (= *latus* Sars).
†*Disseta palumboi* Giesbr.
†*Augaptilus longicaudatus* (Claus).
†*A. megalurus* Giesbr.
†*Euaugaptilus angustus* Sars.
†*E. bullifer* (Giesbr.).
†*E. facilis* (Farran).
†*E. filigerus* (Claus).
†*E. hecticus* (Giesbr.).
†*E. laticeps* Sars.
†*E. magnus* (Wolfend.) (= *validus* A. Scott).
†*E. nodifrons* Sars.
†*E. oblongus* Sars.
E. palumboi Giesbr.
E. spinifrons Sars.
E. squamatus Giesbr.
†*Haloptilus acutifrons* (Giesbr.).
H. angusticeps Sars.
†*H. chierchiæ* Giesbr.
†*H. longicornis* (Claus).
†*H. mucronatus* (Claus).

†*H. ornatus* (Giesbr.).
H. plumosus (Claus).
H. spiniceps (Giesbr.).
Arietellus aculeatus (T. Scott) (= *armatus* Wolfend.).
†*A. setosus* Giesbr.
†*A. simplex* Sars.
†*Phyllopus bidentatus* Brady.
P. helgæ Farran.
†*P. impar* Farran.
Mormonilla phasma Giesbr.

It is probable that further researches will reveal in this region of the Pacific Ocean several other species that have been reported up to the present time from the Atlantic, Indian and south-east Pacific areas, namely :

†*Calanus propinquus* Brady.
†*Calanoides patagoniensis* Brady.
†*Euchirella truncata* Esterly.
†*Valdiviella minor* Wolfenden.
†*Lophothrix humilifrons* Sars.
†*Metridia longa* Lubb.
†*Pleuromamma quadrungulata* (Dahl).
†*Gaussia princeps* (T. Scott).
†*Heterorhabdus vipera* (Giesbr.).
†*Haloptilus oxycephalus* (Giesbr.).
†*Centraugaptilus horridus* (Farran) (= *pyramidalis* Esterly).
†*C. rattrayi* (T. Scott) (= *macrodus* Esterly).

We thus have as many as 166 Atlantic species that appear to have been carried eastward from the Atlantic Ocean into the South-west Pacific region, and of these, 118, marked with a †, have been taken in the Indian Ocean. It is probable that the main transportation of species from the Atlantic Ocean into the Pacific Ocean, as into the Indian Ocean, has been along the easterly branch of the North Atlantic Intermediate current, which, as we have seen, passes across the southern region of the Indian Ocean into the Pacific, and that from this current they have been carried into the Antarctic Intermediate water and so have been swept northwards into both Indian and Pacific Oceans, or, having been carried into the Indian Ocean, they may have passed into the North Indian Intermediate Current and so have reached the south-west Pacific area. A smaller number of Atlantic species may have also followed the more southerly route through the Antarctic region ; there are some 33 such species, namely :

Calanus finmarchicus (Gunn.),
Megacalanus princeps Wolfend.,
Eucalanus elongatus (Dana),
E. longiceps Matthews (? = *acus* Farran),
Rhincalanus nasutus Giesbr.,
Spinocalanus magnus Wolfend.,
Eucætideus giesbrechti (Cleve),

Ætideus armatus (Boeck),
Bradyideus armatus (Vanhöffen),
Gaidius tenuispinus Sars,
Undeuchæta major Giesbr.,
Onchocalanus affinis With,
Scaphocalanus magnus (T. Scott),
Amallothrix emarginata Farran,
A. valida (Farran),
Metridia boecki Giesbr.,
M. brevicauda Giesbr.,
M. princeps Giesbr.,
Pleuromamma abdominalis (Lubb.),
P. borealis (Dahl),
P. gracilis (Claus),
P. robusta (F. Dahl),
P. xiphias (Giesbr.),
Lucicutia bicornuta Wolfend.,
L. magna Wolfend.,
Candacia falcifera Farran,
Heterostylites longicornis (Giesbr.) (= *major* (Dahl)),
Disseta palumboi Giesbr.,
Euaugaptilus laticeps Sars,
Augaptilus megalurus Giesbr.,
Haloptilus longicornis (Claus),
Arietellus setosus Giesbr.,
Phyllopus bidentatus Brady,

and 11 Atlantic species definitely appear to have passed eastward from the Atlantic to the Pacific by this southerly route, since they have not as yet been recorded from the Indian Ocean, namely :

Calanus tonsus Brady.
Spinocalanus abyssalis Giesbr.
S. spinosus Farran.
Scaphocalanus echinatus (Farran).
Onchocalanus cristatus Wolfend.
Scolecithricella ovata (Farran).
Lucicutia grandis (Giesbr.).
Metridia lucens Boeck.
Haloptilus spiniceps (Giesbr.).
? *Phyllopus helgæ* Farran.
Mormonilla phasma Giesbr.

In attributing the distribution of these species to the southern Antarctic route I have assumed that the Antarctic fauna is a circum-polar one, and that from these southerly latitudes species can have been swept towards the equator in either the Antarctic Intermediate Current or the Antarctic Bottom Drift.

We are thus left with some 34 species that have been recorded from both the Atlantic and the South-west Pacific areas but from nowhere in between; these species are as follows:

? *Calanus helgolandicus* (Claus).*
Spinocalanus validus Sars.
S. hirtus Sars.
Mimocalanus cultrifer Farran.
Monacilla typica Sars.
Ætideus bradyi A. Scott.
Ætideopsis multiserrata (Wolfend.).
Pseudotharybdis zetlandicus T. Scott.
Gaidius affinis Sars.
G. notacanthus Sars.
Euchirella amœna Giesbr.
Chiridiella macrodactyla Sars.
Euchæta pubera Sars.
Xanthocalanus agilis Giesbr.
Amallophora typica T. Scott.
Heteramalla dubia T. Scott.
Lophothrix latipes T. Scott.
Scaphocalanus curtus (Farran).
S. major (T. Scott).
Scolecithricella dentata (Giesbr.).
S. longicornis (T. Scott).
S. profunda (Giesbr.).
S. vittata (Giesbr.).
Amallothrix curticauda (A. Scott).
A. obtusifrons Sars.
Lucicutia gemina Farran.
L. longiserrata (Giesbr.).
L. lucida Farran.
Euaugaptilus palumboi Giesbr.
E. spinifrons Sars.
E. squamatus
Haloptilus angusticeps Sars.
H. plumosus (Claus).
Arietellus aculeatus (T. Scott).

Some doubt must remain whether these 34 species actually originated in the Atlantic Ocean, and have been carried into the Pacific Ocean along the easterly flowing branch of the North Atlantic Intermediate Current, without getting caught up in the Antarctic Intermediate Current in the Indian Ocean, and so have what at present appears to be a discontinuous distribution, since further investigations in the Indian or Southern Oceans

* The presence of this species in the south-west Pacific was recorded by Brady, but Sars (1901–3, p. 12) has put forward the view that this record is a false one and is probably due to confusion with another species; *C. helgolandicus* has, however, been recorded more recently by Wilson (1942) from the south-east Pacific area.

may reveal their presence there also: or, alternatively, whether they were in existence in the Atlantic Ocean in Tertiary times, and were swept from thence into the Pacific Ocean at a time when these two oceans were connected by a channel across Central America. Other possible explanations of their distribution is that they have originated in the Pacific Ocean and have been swept eastward past Cape Horn into the South Atlantic Ocean, and then have been carried northwards in the Antarctic Intermediate Current, or that in the Tertiary period they were carried westward by the Tethys Sea. Neither of these two last routes seems to be very likely, for in the case of the first the latest work by Deacon (1937, p. 104) indicates that "the highly saline current from the Indian and Atlantic Oceans is turned towards the north as it approaches the western end of the Drake Passage. . . . The northward movement appears to bring about a large reduction in the volume of the deep water flowing towards the east, and in spite of some indications to the contrary it seems that not more than a comparatively small volume of Indian and Atlantic waters which form the eastward current can enter the Atlantic through the Drake Passage." He further (*loc. cit.*, p. 108) concludes that although the deep water of the Scotia Sea is a comprehensive mixture of Atlantic, Indian and Pacific waters, "it also appears to contain Atlantic water from a direct southward movement over the northern arm of the Scotia Arc and in the lower part of the layer, Weddell Sea deep water which has been formed from a westward movement of Atlantic and Indian deep waters along the Antarctic slope." Such a movement of water is not likely to carry plankton from the Pacific Ocean into the tropical and northern Atlantic Ocean. If the Tethys Sea in times past provided the highway for these species to spread westward from the Pacific to the Atlantic Ocean, we might perhaps expect to find that some of these species would be present to-day in the Mediterranean Sea, though this expectation will depend on the view that we hold regarding the succession of events in the Mediterranean Sea during the last Glacial Period (*vide supra*, p. 473). A comparison of the above list of species with that of the Mediterranean Plankton (*vide supra*, p. 507) reveals that only 6 or 7 species are common to both lists, namely:

? *Calanus helgolandicus* (Claus).
Xanthocalanus agilis Giesbr.
Scolecithricella dentata (Giesbr.).
S. profunda (Giesbr.).
S. vittata (Giesbr.).
Haloptilus angusticeps Sars.
H. plumosus (Claus).

If, on the other hand, the connection of the two oceans across Central America were responsible for the present distribution, we might reasonably expect to find that the majority of these species would still be found inhabiting the eastern Pacific region, but there are again only 7 such, namely:

Calanus helgolandicus (Claus),
Ætideus bradyi A. Scott,
Gaidius affinis Sars,
Euchirella amœna Giesbr.,

Heteramalla dubia T. Scott,
Euaugaptilus palumboi Giesbr.,
? *Lophothrix latipes* T. Scott,

and this last species is doubtful.

I have already (*vide supra*, p. 540) given a list of 30 species that appear to have had their origin in the Indian Ocean, since none of them has as yet been taken in the Atlantic Ocean, and the presence of any of these in the south-west or west Pacific region may well be attributed to the movement of the Indian Intermediate Current. As many as 12 or 14 of these Indian species have apparently been able to survive this transportation and have been recorded from the Pacific Ocean, namely:

? *Bradycalanus typicus* A. Scott.
Undinopsis tropicus Wolfend.
Euchirella bella Giesbr.
E. venusta Giesbr.
Euchæta tenuis Esterly.
Paraeuchæta gracillicauda A. Scott.
P. investigatoris Sewell.
P. malayensis Sewell.
P. spinifera Esterly.
P. tuberculata A. Scott.
P. weberi A. Scott.
? *Scottocalanus investigatoris* Sewell (? = *australis* Farran).
S. farrani A. Scott.
S. thomasi A. Scott.

These have all been recorded from the south-west Pacific region and to these should, in all probability, be added—

Gætanus brevicornis Esterly,
Undeuchæta bispinosa Esterly,
? *Heterorhabdus tanneri* (Giesbr.),

which have been taken in the east Pacific region, though still unknown from the south-west area. Reference to A. Scott's report on the "Siboga" collections shows that the great majority of the examples of the above species were taken in the basins of the Malay Archipelago in depths between 1500 and 2000 m. which are filled (*vide supra*, p. 335) by water that is flowing in from the Pacific Ocean at about this depth, and reference to the chart given by Defant (1928, p. 485, fig. 29) indicates that this water is probably derived from the Antarctic Intermediate Current, though immediately below the Antarctic Intermediate water at about this depth a slight rise in the temperature of the water suggests that there is a flow of Pacific deep water towards the south (*vide* Deacon, 1937, p. 100).

A number of species appear to have had their origin in the south-west Pacific area, since up to the present time they have not been recorded from either the Atlantic or the

Indian Oceans : it is possible that further exploration of the Indian Ocean, and especially of its south-eastern region, may reveal their presence there. These species are as follows :

? *Bradycalanus typicus* A. Scott.*
Tanyrhinus naso Farran.
Eucætideus acutus Farran.
Monacilla dubia A. Scott.
Oxycalanus semispinus A. Scott.
Gaidiopsis crassirostris A. Scott.
Euchirella dentata A. Scott.
E. dubia A. Scott.
E. granulata A. Scott.
Undeuchæta intermedia A. Scott.
Euchæta russelli Farran.
Paraeuchæta dentata A. Scott.
P. propinqua Esterly.
P. sibogæ A. Scott.
Xanthocalanus squamatus Farran.
Bradycalanus gigas A. Scott.
? *Scottocalanus australis* Farran (? = *investigatoris* Sewell).
S. longispinus A. Scott.
S. sedatus Farran.
S. setosus A. Scott.
S. terranovæ Farran.
Scolecocalanus galeatus Farran.
S. lobatus Farran.
Scolecithricella longifurca (Giesbrecht).
Lucicutia philyra A. Scott.
L. pera A. Scott.
Disseta scopularis (Brady).
Euaugaptilus placitus A. Scott.
Paraugaptilus similis A. Scott.
Phyllopus giesbrechti A. Scott.
Bathypontia spinifera A. Scott.
Neopontia typica A. Scott.

The great majority of the above species have not, up to the present time, been recorded from any other area and may be regarded as endemic ; the exceptions to this are—

Euchirella granulata A. Scott,
Paraeuchæta propinqua Esterly,
Scolecithricella longifurca (Giesbr.),

which have been recorded from the east Pacific region, and perhaps to these should be added *Disseta scopularis* (Brady), which was originally described from the North-west Pacific area and which may be represented in the north-east Pacific region by *Disseta*

* A young example that appears to belong to the genus *Bradycalanus* A. Scott was, as noted above (p. 330), taken by the " John Murray " Expedition in Indian waters and may be a young stage of *B. typicus* A. Scott.

maxima Esterly, for *scopularis* is known only from the male and *maxima* only from the female.

There seems to be somewhat less movement of the deep Arctic water in the Pacific than in the Atlantic or Indian oceans: according to Defant (1928), in the most northern part of this ocean a relatively small mass of water appears to make its way southwards in the Okhotsk Current, and is to be found on the west side at a depth of some 500–1500 m. between lats. 15° and 50° N.; Wüst, however, has put forward the view that the Arctic Intermediate current in this ocean is a strong current which flows southward until it meets the Antarctic current near the Equator. Below a depth of some 2000 m. in the central part of the Pacific lies a mass of water which, according to Sverdrup, extends on the north-eastern side of a line drawn from a point at lat. 40° S., long. 100° W. through Fiji to Japan, and this mass he attributes to an eastward current of water from the Atlantic and Indian Antarctic Oceans, especially the latter, which enters the Pacific Ocean south of Australia (*vide* Deacon, 1937, p. 100).

The greater part of the Pacific Ocean appears to be filled with this water that is very uniform in salinity and temperature, and there is no obvious mass of warm intermediate water, such as we have seen in the North Atlantic and North Indian regions, flowing southward from the north to the south Pacific regions to form an intermediate current; but it appears probable that there is a slow movement of water from north to south, and that some at least of this "intermediate" water swings eastward between Cape Horn and the Antarctic continent. In southern latitudes the last part of the Antarctic Bottom Drift passes right across the Pacific Ocean, and reaches as far as the western side of Graham Land but no further: as Deacon (1938) points out, "on the east side (of Graham Land) the bottom water is newly formed, but on the west side it has travelled round the whole (Antarctic) continent." Deacon (1938) also points out that the recent observations of the "Discovery" "confirm the theories put forward by Professor Wüst, Dr. Möller and Dr. Sverdrup as to the existence of an eastward movement from the Atlantic Ocean through the Indian Ocean to the Pacific Ocean in the warm deep layer; they show that the deep current is almost circumpolar, and while some of it spreads northwards with the Antarctic bottom water, there appear to be compensating movements towards the south in the upper part of the current. In the Indian Ocean such a movement is likely to contain a mixture of waters from the North Indian deep current and the Antarctic Intermediate Current, and in the Pacific Ocean a mixture of waters from the intermediate and bottom currents formed somewhere in the tropical part of the ocean."

With any reduction in the amount of flow of the Sub-polar intermediate water and its failure to pass across the Equator or beyond lat. 15° N., we should expect to find a corresponding reduction in the number of Atlantic and Indian species that have been recorded from the north-west Pacific area, when compared with the catches made in the northern region of the Indian Ocean or in the south-west and south-east Pacific areas.

Our knowledge of the fauna of the north-west region of the Pacific Ocean is still somewhat scanty, and is derived mainly from the work of Giesbrecht (1892), Kurasige (1901), Marukawa (1921), Mori (1932), Tanaka (1937) and Wilson (1942). Unfortunately the work of the "Carnegie," with which Wilson's report deals, was limited to the top 100 m., and hence there can be little doubt that many more deep-dwelling species still await discovery. Our knowledge of the north-east Pacific region is more extensive, thanks to the work of Giesbrecht (1892 and 1895), Esterly (1905, 1906, 1911, 1913 and 1924),

Campbell (1929) and Wilson (1942). I have given below the species that have been recorded from these two areas :

West and North-west Pacific area.	East and North-east Pacific area.
**Calanus cristatus* Kröyer.	*Calanus cristatus* Kröyer.
**C. finmarchicus* (Gunn.).	*C. finmarchicus* (Gunn.).
**C. helgolandicus* (Claus).	..
..	**C. hyperboreus* Kröyer.
**C. propinquus* Brady.	*C. propinquus* Brady.
C. syumpuensis Kurasige.	..
**C. tenuicornis* Dana.	*C. tenuicornis* Dana.
**C. tonsus* Brady (= *plumchrus* Marukawa).	..
**Calanoides brevicornis* (Lubb.).	..
**Neocalanus gracilis* (Dana).	*Neocalanus gracilis* (Dana).
**N. robustior* (Giesbr.).	*N. robustior* (Giesbr.).
**Megacalanus princeps* Wolfend.†	*Megacalanus princeps* Wolfend.
**Bathycalanus princeps* Brady (= *rigidus* Sars).	*Bathycalanus princeps* Brady.
**Ctenocalanus vanus* Giesbr.	*Ctenocalanus vanus* Giesbr.
**Microcalanus pusillus* Sars.	*Microcalanus pusillus* Sars.
**Pseudocalanus elongatus* (Boeck).	*Pseudocalanus elongatus* (Boeck).
**Eucalanus attenuatus* (Dana).	*Eucalanus attenuatus* (Dana).
..	*E. bungii* Giesbr. f. *bungii*.‡
..	*E. bungii* Giesbr. f. *californicus*.
**E. elongatus* (Dana).	*E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.	*Rhincalanus nasutus* Giesbr.
**Spinocalanus abyssalis* Giesbr.	*Spinocalanus abyssalis* Giesbr.
..	**S. caudatus* Sars.
..	**S. magnus* Wolfend.
..	*S. major* Esterly.
**Euaetideus giesbrechti* (Cleve).	..
**Ætideus armatus* (Boeck).	*Ætideus armatus* (Boeck).
..	*Ætideopsis divaricata* Esterly.
..	*Æ. pacifica* Esterly.
**Chiridius poppei* Giesbr.	*Chiridius poppei* Giesbr.
?**C. gracilis* Farran.	..

† As Vervoort (1946, p. 56) has pointed out, the "species" described by Marukawa (1921, p. 13, pl. i, figs. 10–13 and pl. ii, figs. 1–4) under the name *Pseudolovenula magna* gen. et sp. nov., is a young stage of a species belonging to the Family Megacalanidæ nov. Vervoort suggests that it is an example of the IVth Copepodid stage of *Megacalanus princeps* Wolfend., but this, I think, is improbable, since Marukawa has shown the posterior thoracic margin as uniformly rounded, whereas in *M. princeps* it is produced in a rounded projection, and the 2nd basal segment of the 1st leg shows no sign of the spine that is characteristic of this species.

‡ Vervoort (1946, p. 91), from a study of the examples of the species of *Eucalanus* in the "Snellius" collections from the Malay Archipelago, has reached the conclusion that the separation of *Eucalanus elongatus* and *E. bungii* cannot be maintained, and that it is only possible to recognize an Atlantic form with a spinous process on the 5th thoracic segment and a Pacific form with a smoothly rounded posterior thoracic margin.

* Denotes a North Atlantic species.

West and North-west Pacific area.	East and North-east Pacific area.
..	*_Chirundina streetsi_ Giesbr.
Paratharybdis frontalis Tanaka.	..
..	*_Gætanus armiger_ Giesbr.
..	_G. ascendens_ Esterly.
..	_G. brevicornis_ Esterly (= _rectus_ Wolf.).
..	_G. intermedius_ Campbell.
..	*_G. latifrons_ Sars.
..	*_G. miles_ Giesbr.
*_Gætanus minor_ Farran.	_G. minor_ Farran.
..	*_G. kruppi_ Giesbr. (= _clarus_ Esterly).
..	*_G. pileatus_ Farran (= _caudani_ auct.).
..	_G. secundus_ Esterly.
..	_Gaidius pungens_ Giesbr.
*_Gaidius tenuispinus_ Sars.	_G. tenuispinus_ Sars.
..	*_Euchirella amœna_ Giesbr.
*_Euchirella brevis_ Sars	_E. brevis_ Sars.
*_E. curticauda_ Giesbr.	_E. curticauda_ Giesbr.
..	*_E. galeata_ Giesbr. (? = _bitumida_ With).
..	_E. granulata_ A. Scott.
..	*_E. messinensis_ (Claus).
..	_E. propria_ Esterly.
*_E. pulchra_ (Lubb.).	_E. pulchra_ (Lubb.).
*_E. rostrata_ (Claus).	_E. rostrata_ (Claus).
..	_E. simplex_ Esterly.
..	*_E. truncata_ Esterly (= _intermedia_ With).
..	_Undeuchæta bispinosa_ Esterly.
..	_U. incisa_ Esterly (? = _superba_ With).
*_Undeuchæta major_ Giesbr.	_U. major_ Giesbr.
*_U. plumosa_ (Lubb.).	_U. plumosa_ (Lubb.).
..	_Euchæta diegensis_ Esterly.
Euchæta japonica Marukawa.	_E. japonica_ Marukawa (? = _elongata_ Esterly).
..	_E. solida_ Esterly (= _tenuis_ Esterly).
..	*_E. spinosa_ Giesbr.
..	_E. tenuis_ Esterly.
..	_Paraeuchæta californica_ (Esterly).
..	_P. dubia_ (Esterly).
Paraeuchæta flava (Giesbr).	..
..	_P. propinqua_ (Esterly).
..	_P. spinifera_ (Esterly).
*_P. tonsa_ (Giesbr.).	_P. tonsa_ (Giesbr.).
*_Phænna spinifera_ Claus.	_Phænna spinifera_ Claus.
Xanthocalanus medius Tanaka.	..
..	_Xanthocalanus pulcher_ Esterly.

West and North-west Pacific area.	East and North-east Pacific area.
..	*X. similis* Esterly.
..	*X. tectus* Esterly.
..	**Heteramalla dubia* (T. Scott).
Onchocalanus nudipes Wilson.	*Onchocalanus nudipes* Wilson.
..	*O. latus* Esterly.
**Scottocalanus securifrons* (T. Scott).	..
..	**Scottocalanus persecans* (Giesbr.).
..	**Lophothrix frontalis* Giesbr.
..	**L. latipes* (T. Scott).
Scaphocalanus gracillicauda Tanaka.	..
..	**Scaphocalanus magnus* (T. Scott).
S. minutus Tanaka.	..
S. pacificus Mori.	..
**Scolecithricella abyssalis* (Giesbr.).	*Scolecithricella abyssalis* (Giesbr.).
..	*S. aculeata* (Esterly).
..	*S. angusta* Esterly.
**S. auropecten* (Giesbr.).	*S. auropecten* (Giesbr.).
**S. ctenopus* (Giesbr.).	*S. ctenopus* (Giesbr.).
**S. dubia* (Giesbr.).	..
..	*S. elephas* (Esterly).
..	*S. longirostris* (Esterly).
S. marginata (Giesbr.).	*S. marginata* (Giesbr.).
..	*S. mollis* (Esterly).
..	*S. pacifica* Esterly.
..	*S. obscura* (Esterly).
S. porrecta (Giesbr.).	*S. porrecta* (Giesbr.).
..	**S. similis* (T. Scott).
..	*S. subdentata* Esterly.
..	*S. vorax* Esterly.
**Amallothrix emarginata* (Farran).	*Amallothrix emarginata* (Farran) (= *inornata* (Esterly)).
..	**Temoropia mayumbæensis* T. Scott.
..	**Metridia bœcki* (Giesbr.).
**Metridia brevicauda* Giesbr.	*M. brevicauda* Giesbr.
..	*M. curticauda* Giesbr.
..	*M. ignota* Esterly.
**M. longa* Lubb.	..
**M. lucens* Boeck.	*M. lucens* Boeck.
..	**M. princeps* Giesbr.
**M. venusta* Giesbr.	*M. venusta* Giesbr.
**Pleuromamma abdominalis* (Lubb.).	*Pleuromamma abdominalis* (Lubb.).
P. gracilis (Claus) (? *borealis* (Dahl)).	*P. gracilis* Claus ?
..	**P. quadrungulata* (Dahl).
**P. robusta* (F. Dahl).	*P. robusta* (F. Dahl).

West and North-west Pacific area.	East and North-east Pacific area.
*_P. xiphias_ (Giesbr.).	_P. xiphias_ (Giesbr.).
..	*_Gaussia princeps_ (T. Scott) (=_atra_ Esterly).
*_Lucicutia clausi_ (Giesbr.).	_Lucicutia clausi_ (Giesbr.).
*_L. grandis_ (Giesbr.).	_L. grandis_ (Giesbr.).
..	*_L. longicornis_ (Giesbr.).
*_L. longiserrata_ (Giesbr.).	..
..	*_L. ovalis_ Wolfend.
..	*_Heterorhabdus abyssalis_ (Giesbr.).
*_Heterorhabdus clausi_ (Giesbr.).	_H. clausi_ (Giesbr.).
*_H. papilliger_ (Claus).	_H. papilliger_ (Claus).
*_H. spinifrons_ (Claus).	_H. spinifrons_ (Claus).
..	_H. tanneri_ (Giesbr.).
..	*_H. vipera_ (Giesbr.).
..	*_Heterostylites longicornis_ (Giesbr.).
..	_Disseta maxima_ Esterly (? = _scopularis_ Brady).
*_Disseta palumboi_ Giesbr.	_D. palumboi_ Giesbr. (= _grandis_ Esterlv).
D. scopularis Brady.	..
..	*_Augaptilus longicaudatus_ (Claus).
..	*_A. megalurus_ Giesbr.
*_Euaugaptilus bullifer_ (Giesbr.).	..
..	_Euaugaptilus californicus_ (Esterly).
..	_E. depressus_ (Esterly).
..	*_E. hecticus_ (Giesbr.).
..	_E. lamellifer_ Esterly.
..	*_E. nodifrons_ Sars (? = _simplex_ Wolfend.).
*_E. palumboi_ Giesbr.	_E. palumboi_ Giesbr.
..	_E. romanus_ (Esterly). ♂ only.
..	_E. rostratus_ Esterley.
*_E. squamatus_ Giesbr.	..
..	*_Centraugaptilus horridus_ (Farran) (= _pyramidalis_ (Esterly)).
..	_C. lucidus_ Esterly.
..	*_C. rattrayi_ (T. Scott) (= _macrodus_ Esterly).
..	_C. porcellus_ Johnson.
*_Haloptilus acutifrons_ (Giesbr.).	_Haloptilus acutifrons_ (Giesbr.).
*_H. angusticeps_ Sars.	..
..	*_H. chierchiæ_ (Giesbr.).
*_H. longicornis_ (Claus).	_H. longicornis_ (Claus).
*_H. ornatus_ (Giesbr.).	_H. ornatus_ (Giesbr.).
..	*_H. oxycephalus_ (Giesbr.).
*_H. plumosus_ (Claus).	_H. plumosus_ (Claus).
*_H. spiniceps_ (Giesbr.).	_H. spiniceps_ (Giesbr.).

West and North-west Pacific area.	East and North-east Pacific area.
..	_Arietellus pacificus_ Esterly.
..	*_A. setosus_ Giesbr.
..	*_A. simplex_ Sars (= _major_ Esterly).
..	*_Paraugaptilus buchani_ Wolfend.
..	*_Phyllopus bidentatus_ Brady.
? *_Phyllopus helgæ_ Farran.	..
..	_P. integer_ Esterly.

In the north-west and west Pacific region we have records of 75 deep-sea species, and of these as many as 62, marked by an asterisk, are known to occur in the North Atlantic Ocean: but of these species, 13 are in all probability really boreal-Arctic in their habitat, and have been swept into both the Atlantic and Pacific Oceans by currents flowing southwards. These Arctic species are—

Calanus cristatus Kröyer,
C. finmarchicus (Gunn.),
C. helgolandicus (Claus),
C. tonsus Brady,
Ctenocalanus vanus Giesbr.,
Microcalanus pusillus Sars,
Pseudocalanus elongatus (Boeck),
Spinocalanus abyssalis Giesbr.,
Ætideus armatus Brady,
Gaidius tenuispinus Sars,
Metridia longa Lubb,
Haloptilus acutifrons (Giesbr.),
H. spiniceps (Giesbr.),

and to these we should perhaps add _Euchirella rostrata_ (Claus), which, though not recognized as a true arctic species, has been recorded from the Arctic region on the west coast of Greenland as far north as lat. 63° 50′ N., long. 54° 25′ W., and _Eucalanus bungii_ Giesbr. with its two subspecies _bungii_ and _californicus_ Johnston, which, according to Johnson (1938), appears to have been swept into the north Pacific area from the Arctic, or at least from the Alaskan region through the Bering Sea.

If we exclude these Arctic species we are left with 47 species that in all probability originated in the North Atlantic Ocean and have spread thence to the north-west Pacific region, and 40 of these have been taken in both the Indian Ocean and the south-west Pacific area. Seven other species, namely:

Metridia lucens Boeck.,
Lucicutia grandis (Giesbr.),
L. longiserrata (Giesbr.),
Euaugaptilis palumboi Giesbr.,
E. squamatus Giesbr.,
Haloptilus plumosus (Claus),
Phyllopus helgæ Farran,

are known from the Atlantic and south-west Pacific regions, though they have not as yet been recorded from the Indian Ocean.

As regards the influx from the Arctic Ocean into the north Pacific Ocean, Defant (1928) remarks : " Vom Ochotskischen Meere im Westen, vom Bering-Meere in der Mitte geht im Norden der arktische Zwischenstrom aus. Seine Ausbildung steht jener des antarktischen kaum nach ; die Tiefenlage seine Kernschicht ist 800 bis 900 m. im Westen, 800 m. om Zentralschnitt, seine Reichweite gegen Süden im Westen bis etwa 10° N., in der Mitte bis etwa 15° N." The Okhotsk Sea, however, is not itself connected with the Arctic Ocean, and the influx of Arctic water into the Pacific Ocean must come through the Bering Sea ; this seems to be brought about by the Oya-shio Current that runs southward on the west side of the Bering Sea. There seems little or no reason to doubt that the true Atlantic species have been swept eastward from the south Atlantic Ocean in the eastern branch of the North Atlantic Intermediate Current across the southern part of the Indian Ocean, and past the south of Australia into the south-west Pacific region, and have made their way northwards up the west side of the Pacific Ocean, so that many have reached the region round Japan. A few species may have reached this region by more than one route, for of the various species noted above that seem to have come in from the Arctic Ocean, at least four have been taken in areas along the course of the North Atlantic Intermediate Current ; thus *Gaidius tenuispinus* Sars, *Metridia longa* Lubb. and *Haloptilus acutifrons* (Giesbr.) have been recorded from the Indian Ocean, into which they cannot possibly have been carried by a current from the Arctic Ocean and must have been introduced from the southern side, and *Spinocalanus abyssalis* Giesbr. and *Haloptilus spiniceps* (Giesbr.) are known from the south-west Pacific region, though they have not as yet been taken in the Indian Ocean. It may be that these last two are members of a group of species that have been carried from the Atlantic Ocean southwards into the Antarctic region, and have made their way thence into the Pacific Ocean by the Antarctic Intermediate Current, for there are in all some 25 species that are known from the North Atlantic and Antarctic oceans and have also been taken in the north-west Pacific region, and some of these have not been recorded from the Indian Ocean, as for instance *Metridia lucens* Boeck, *Lucicutia grandis* (Giesbr.) and *Phyllopus helgæ* Farran.

It is interesting to note that up to the present time not a single species that has originated in the Indian Ocean, a list of which is given above (*vide supra*, p. 540), has been recorded from the north-west Pacific area, and only two species that seem to have had their origin in the south-west Pacific area, namely *Disseta scopularis* Brady and *Euaugaptilus squamatus* Giesbr., appear to have been able to get to this region, and this is in agreement with what we know of the movement in the western region of the Antarctic Intermediate Water.

As in other areas, a certain number of species appear to have arisen in this region and may be regarded as indigenous, namely :

Calanus syumpuensis Kurasige.
Paratharybdis frontalis Tanaka.
Euchæta japonica Marukawa (? = *elongata* Esterly).
Xanthocalanus medius Tanaka.
Onchocalanus nudipes Wilson.
Scaphocalanus gracillicauda Tanaka.
S. minutus Tanaka.

Scaphocalanus pacificus Mori.
Scolecithricella marginata (Giesbr.).
Scolecithricella porrecta (Giesbr.).
Paraeuchaeta flava (Giesbr.).

It seems to be possible, though not easy, for species to be carried from the north-west area of the Pacific ocean to the north-east side, for of the above only three appear to have spread eastward. Of these *Euchaeta japonica* Marukawa seems to me to be the same species as *E. elongata* Esterly, and *Onchocalanus nudipes* Wilson and *Scolecithricella porrecta* (Giesbr.) have been recorded from both the north-east and south-east regions of the Pacific Ocean.

From the north-east region of the Pacific I have been able to collate references to as many as 143 species of deep-sea Copepods, and of these only 54 have been recorded from the north-west region: 91 species are known to occur in the Atlantic Ocean, but of these as many as 42 have not yet been recorded from the north-west Pacific area. Such a marked difference must be attributed at least in part to the more intensive study that has been made in the north-east area, especially by Esterly, but it seems possible that it may in part be due to the distribution of the deep-water currents in the mid-Pacific region, and more particularly to the manner in which the Atlantic-Indian Intermediate Current spreads out towards the north and east in this ocean. A certain number of species appear to have reached this north-eastern area either directly, or indirectly through the north-western region, from the Arctic Ocean, the only differences between the two areas being that whereas *Calanus helgolandicus* (Claus) has been recorded from the west side, its place is taken on the east side by *Calanus hyperboreus* Kröyer, and the presence on the east side of *Eucalanus bungii* Giesbr. and its two subspecies.* Johnson (1938) remarks that the oceanic circulation of the North Pacific, so far as it is known, lends support to the idea that the route followed in the development of these subspecies may well be northwards along the Asiatic coast and southwards along the American coast. The subspecies *bungii bungii* is a boreal and sub-boreal form from the Bering Sea and extends along the Californian coast as far as lat. 50° N., and *bungii californicus* has been taken as far north as lat. 50° N., but its southern limit is not known. They would thus seem to follow the general trend of the surface circulation, namely the Kuro-siwo, the North Pacific Drift and the California Current, clockwise round the North Pacific Ocean.

Of the 88 species that are known from the north-east Pacific region, but have not as yet been taken in the north-west area, half, 42 in all, are Atlantic forms and are widely distributed, 34 of them being known from the Indian Ocean, though 5 of these last have not as yet been recorded from the south-west Pacific region. These five species are:

Pleuromamma quadrungulata (Dahl).
Gaussia princeps (T. Scott).
Heterorhabdus vipera (Giesbr.).
Centraugaptilus horridus (Farran).
C. rattrayi (T. Scott).

* Giesbrecht (1892, p. 149) recognized several varieties of the species *Eucalanus elongatus* (Dana), namely *hyalinus*, an Atlantic form with points on the 5th thoracic segment, *inermis* with the 5th thoracic segment smoothly rounded and with marked pubescence on the free thoracic segments and the abdomen, and *bungii*, resembling *inermis*, but with a head longer and more pointed. Johnson (1938) has raised *bungii* to the rank of a species and has described two subspecies, *bungii* and *californicus*.

Three species have been recorded from the Atlantic and the south-west Pacific areas, but have not yet been recorded from the Indian Ocean, namely :

Euchirella amœna Giesbr.
Heteramalla dubia (T. Scott).
Lophothrix latipes (T. Scott).

It seems highly probable that further researches will reveal the presence of these species in the intermediate areas.

Of the species that seem to have originated in the Indian Ocean (*vide supra*, p. 540), 4 or 5 have succeeded in penetrating into this north-east area of the Pacific, namely :

Gætanus brevicornis Esterly,
Undeuchæta bispinosa Esterly,
Euchæta tenuis Esterly,
Paraeuchæta spinifera Esterly,

and perhaps *Heterorhabdus tanneri* Giesbr.

Three, or possibly four, species that seem to have originated in the south-west Pacific area have turned up again in the north-east region, namely :

Euchirella granulata A. Scott,
Paraeuchæta propinqua Esterly,
Scolecithricella longifurca (Giesbr.),

and possibly *Disseta scopularis* Brady, if this last is the same species as *D. maxima* Esterly, as seems at least possible, for *D. scopularis* is known only from the male and *D. maxima* only from the female. The evidence appears to indicate that there is a greater connection between the south-west Pacific and Indian regions with the north-east Pacific area than with the north-west region of the Pacific. This may perhaps be explained, if we adopt Wüst's view (*vide supra*, p. 554), by the greater volume of the Arctic Intermediate water in the Pacific Ocean as compared with the Atlantic Ocean, and the fact that the rotation of the earth will tend to throw this southerly moving current of water on to the asiatic or west side of the Ocean, and thus prevent the northward spread of species beyond the Equator on this side of the Ocean, or, if we follow Sverdrup, to the mass of water, derived from the Atlantic and Indian Oceans, that fills the basin of the Pacific to the east and north-east of the line drawn from Fiji to Japan and which enters this ocean to the south of Australia.

A number of species, 37 in all, have now been recorded from the north-east Pacific region, but have not been taken in any other area ; and it seems probable that they are indigenous and endemic in this region. These species are as follows :

Spinocalanus major Esterly.
Ætideopsis divaricata Esterly.
Æ. pacifica Esterly.
Gætanus secundus Esterly.

G. ascendens Esterly.
Euchirella propria Esterly.
E. simplex Esterly.
E. solida Esterly, ♂.
? *Undeuchaeta incisa* Esterly (? = *superba* With).
Paraeuchaeta californica (Esterly).
P. dubia (Esterly).
Xanthocalanus pulcher Esterly.
X. similis Esterly.
X. tectus Esterly.
Onchocalanus latus Esterly.
Scolecithricella aculeata (Esterly).
S. angusta (Esterly).
S. elephas (Esterly).
S. longirostris (Esterly).
S. mollis (Esterly).
S. pacifica Esterly.
S. obscura (Esterly).
S. subdentata Esterly.
S. vorax Esterly.
Lucicutia longicornis (Giesbr.).
Metridia ignota Esterly.
? *Disseta maxima* Esterly.
Euaugaptilus californicus (Esterly).
E. depressus (Esterly).
E. lamellifer Esterly.
E. romanus (Esterly).
E. rostratus Esterly.
Centraugaptilus lucidus Esterly.
C. porcellus Johnson.
Arietellus pacificus Esterly.
A. major Esterly.
Phyllopus integer Esterly.

Up to the present time not a single one of these species has been reported from any other area, and a possible explanation of this limited distribution may perhaps be found in the character of the water movements in this ocean. Deacon (1945), in a review of the oceanographical results of the last voyage of the "Carnegie," remarks that "the measurements confirm that no highly saline water sinks from the surface into the deep layer and highest salinities in the deep water are found near the bottom, where water of Atlantic and Indian Ocean origin creeps slowly northwards from the Southern Ocean. Compared with the deep-water circulation in the Atlantic Ocean, the Pacific deep water movements are very sluggish." It thus seems probable that any "migration" southwards from this northern region of the Pacific Ocean would be against the current.

There are two or three species that have, up to the present time, been recorded from

this north-east region of the Pacific Ocean and the Atlantic Ocean only : these are—

? *Undeuchæta incisa* Esterly (? = *U. superba* With).
Amallophora similis T. Scott.
Paraugaptilus buchani Wolfend.

As regards the first, if I am right in thinking that *Undeuchæta superba* and *U. incisa* are synonyms, this species may have entered the north Pacific area from the Arctic region through the Bering Strait, for *U. superba* has been recorded by With (1915) from as far north in the Atlantic Ocean as lat. 65° N. off the east coast of Greenland and in the Faroe-Iceland Channel. In both *Amallophora* and *Paraugaptilus* we have small genera composed of only very few species. In *Amallophora* two species, *typica* and *similis*, occur in the Atlantic Ocean, and of these *similis* has managed to get into the south-west and north-east areas of the Pacific Ocean. Similarly, in the genus *Paraugaptilus*, *P. buchani* occurs in both the north Atlantic and in the north-east Pacific areas, while the second species in the genus, *similis*, has been taken only in the south-west Pacific region. It seems probable that we have here two rare genera which originated in the North Atlantic Ocean and have been swept southwards and then eastwards, as so many other species and genera appear to have been, and that in the genus *Paraugaptilus* transference from one habitat to another has been accompanied by the evolution of a new species, *Paraugaptilus similis*, in the south-west Pacific.

The south-east region of the Pacific is perhaps the least known of all the oceanic areas, and we are dependent on Giesbrecht (1892) and Wilson (1942) for the relatively little that we know. It seems possible that in one part of this area conditions are unfavourable for the existence of many planktonic organisms. Agassiz (1906) found that the northern limit of this unfavourable area " forms a regular curve from off the Paumotus, cutting long. 100° W. at 10° S. lat., and thence curves in an easterly and south-south-easterly direction, cutting lat. 20° S. at about 84° W. long." ; he also notes that " the southern limit of the poor pelagic trawls begins off the east face of the Paumotus, running east, somewhat north and south of lat. 20° S. to about 95° W. long., when it runs off in a south-easterly direction." Within this area Agassiz found that all trawls between 300 and 800 fms. (550 and 1460 m.) yielded in the main only dead and decomposing material, and in one instance as many as 65% of the Copepoda were dead. Graham (1943), from his examination of the catches of Phyto-plankton made by the " Carnegie " in her last cruise, reached the conclusion that in the south-east part of the Pacific Ocean between the coast of South America and long. 120° W. there is a barren region with a very low plankton production ; this area is bounded by the edges of what he terms the Antarctic Drift (presumably by this he means the West Wind Drift), the Peruvian Current and the westward extension of the Peruvian Current. Wilson (1942, p. 7), in his comparison of the different parts of the Pacific Ocean, notes that " in the South Pacific the stations yielding the most species were located in the eastern part alongside the Humbolt Current and in the western part north of the Samoan Islands." During the " Carnegie " 's last cruise the barren area noted by Agassiz was crossed twice, once between Stas. 44 and 50 and again between Stas. 56 and 70, while Stas. 70 to 95 run from east to west along the line of this barren area. It is extremely interesting to compare the numbers of deep-sea species that were captured in the various tow-nettings at these stations and I have tabulated these below : at most stations three serial tow-nettings, at 0 m., 50 m. and 100 m.

depth, were taken at each station, but at some of them only one or two tow-nettings were taken, and I have indicated these by an asterisk :

Number of Station.		Number of deep-sea Copepoda.	Number of Station.		Number of deep-sea Copepoda.	Number of Station.		Number of deep-sea Copepoda.
44	..	22	56	..	25	74	..	14
45	..	10	57	..	14	75	..	15
46	..	5	58	..	10	*76	..	4[1]
47	..	5	59	..	5	*77	..	—[2]
48	..	10	60	..	1	*78	..	8[1]
49	..	14	61	..	7	79	..	9
50	..	16	62	..	5	*80	..	8[3]
			63	..	4	*81	..	9[3]
			64	..	5	*82	..	6[3]
			65	..	10	*83	..	6[3]
			*66	..	9[1]	*84	..	5[3]
			67	..	8	*85	..	10[3]
			68	..	11	*86	..	4[3]
			69	..	16	*87	..	7[3]
						*88	..	4[3]
						*89	..	8[3]
						*90	..	3[3]
						*91	..	5[3]
						*92	..	4[3]
						*93	..	7[3]
						94	..	9
						*95	..	12[4]
						96	..	12
						97	..	14

[1] At 0 and 100 m.
[2] At 0 m. only.
[3] At 0 and 50 m. only.
[4] At 50 and 100 m. only.

These figures certainly seem to corroborate the assertion that in this region there is a considerable reduction in the number of species of deep-sea Copepoda, though the paucity of numbers of species taken within the top 100 m. may be due to a condition of stability in the water layers and an absence of turbulence. In the deeper levels the density of population does not appear to be affected, for at " Carnegie " Sta. 64, where a tow-netting was taken at a depth of 1000 m., the number of deep-sea species captured was 47.

From this south-east region of the Pacific Ocean I have been able to collate records of the occurrence of 92 different deep-sea species, namely :

***Calanus finmarchicus* (Gunn.).
**C. helgolandicus* (Claus).
**C. propinquus* Brady.
**C. tenuicornis* Dana.
**C. tonsus* Brady.

Calanoides patagoniensis (Brady).
**Neocalanus gracilis* (Dana).
**N. robustior* (Giesbr.).
**Megacalanus princeps* Wolfend.
**Bathycalanus princeps* Brady.
**Microcalanus pusillus* Sars.
**Pseudocalanus minutus* Kröyer (= *elongatus* (Boeck)).
**Eucalanus attenuatus* (Dana).
**E. elongatus* (Dana).
**Rhincalanus nasutus* Giesbr.
**Spinocalanus abyssalis* Giesbr.
**S. caudatus* Sars.
**S. magnus* Wolfend.
**Euchætideus giesbrechti* (Cleve).
**Ætideus armatus* (Boeck).
**Æ. bradyi* A. Scott.
**Gætanus armiger* Giesbr.
**G. kruppi* Giesbr.
**G. miles* Giesbr.
**G. minor* Farran.
**Gaidius affinis* Sars.
**G. tenuispinus* Sars.
Euchirella bella Giesbr.
**E. brevis* Sars.
**E. curticauda* Giesbr.
**E. intermedia* With (= *truncata* Esterly).
**E. messinensis* (Claus).
**E. galeata* Giesbr. (? = *bitumida* With).
**E. pulchra* (Lubb.).
**E. rostrata* (Claus).
**Undeuchæta major* Giesbr.
**U. plumosa* (Lubb.).
**Undinopsis bradyi* Sars.
**Pseudochirella divaricata* (Sars).
**Valdiviella minor* Wolfend.
**Paraeuchæta incisa* (Sars).
**P. tumidula* (Sars).
**Phænna spinifera* Claus.
Onchocalanus nudipes Wilson.
**Heteramalla dubia* (T. Scott).
**Lophothrix frontalis* Giesbr.
**L. humilifrons* Sars.
**Scaphocalanus magnus* (T. Scott).
**S. medius* Sars.
**Scolecithricella abyssalis* (Giesbr.).
**S. auropecten* (Giesbr.).

S. marginata (Giesbr.).
S. porrecta (Giesbr.).
S. spinacantha Wilson.
**Amallothrix emarginata* (Farran).
**A. obtusifrons* Sars.
**A. propinqua* Sars.
**Metridia bœcki* Giesbr.
**M. brevicauda* Giesbr.
**M. curticauda* Giesbr.
**M. longa* (Lubb.).
**M. lucens* Boeck.
**M. princeps* Giesbr.
**Pleuromamma abdominalis* (Lubb.).
**P. gracilis* (Claus).
**P. quadrungulata* (Dahl).
**P. robusta* (Dahl).
**P. xiphias* (Giesbr.).
**Lucicutia bicornuta* Wolfend.
**L. clausi* (Giesbr.).
**L. curta* Farran.
**L. longicornis* (Giesbr.).
**Heterorhabdus abyssalis* (Giesbr.).
**H. compactus* Sars.
**H. papilliger* (Claus).
**H. spinifrons* (Claus).
**H. vipera* (Giesbr.).
**Heterostylites longicornis* (Giesbr.).
**Augaptilus longicaudatus* (Claus).
**Euaugaptilus filigerus* (Claus).
**Haloptilus acutifrons* (Giesbr.).
**H. chierchiæ* (Giesbr.).
**H. longicornis* (Claus).
**H. ornatus* (Giesbr.).
**H. oxycephalus* (Giesbr.).
**H. plumosus* (Claus).
**H. spiniceps* (Giesbr.).
**Isochæta ovalis* Giesbr.
**Phyllopus bidentatus* Brady.
**P. helgæ* Farran.
**Mormonilla minor* Giesbr.
**M. plasma* Giesbr.

Of the above species no less than 86 are known to inhabit the Atlantic Ocean, thus constituting 93·5 per cent. of the total population. I have marked these species in the above list with an asterisk. Of the remaining 6 species, two—

Calanoides patagoniensis (Brady),
Euchirella bella Giesbr.,

have been recorded from the Indian Ocean. Four species, namely—

Scolecithricella spinacantha Wilson,
S. marginata Giesbr.,
S. porrecta (Giesbr.).
Onchocalanus nudipes Wilson,

appear to be confined to the Pacific Ocean and may be regarded as indigenous, and possibly endemic, the three last occurring in both the north-east and north-west areas.

I have already called attention to the present state of our knowledge of the deep water movements in the southern Pacific Ocean (*vide supra*, p.554), and the composition of the deep-water copepod fauna is exactly what one would expect to find. The great majority of the species recorded from this south-east region can have been transported eastward in the Atlantic-Indian Intermediate water, and most of them have already been recorded from both the Indian Ocean and the south-west Pacific region ; there are, however, certain species that have not been recorded from one or other section of this southern route.

The following twelve species have so far not been recorded from the Indian Ocean :

†*Calanus tonsus* Brady,
†*Spinocalanus abyssalis* Giesbr.,
Ætideus bradyi A. Scott,
Gaidius affinis Sars,
Heteramalla dubia (T. Scott),
Amallothrix propinqua Sars,
†*Metridia lucens* Boeck,
Haloptilus plumosus (Claus),
†*H. spiniceps* (Giesbr.),
†*Phyllopus helgæ* Farran,
Mormonilla minor Giesbr.,
†*M. phasma* Giesbr.,

and a further group of seven, though present in the Indian Ocean, have not been recorded from the south-west Pacific region, namely :

†*Spinocalanus magnus* Wolfend.
†*Euchirella rostrata* (Claus).
Valdiviella minor Wolfend.
Lophothrix humilifrons Sars.
†*Metridia longa* (Lubb.).
Heterorhabdus vipera (Giesbr.).
†*Haloptilus oxycephalus* (Giesbr.).

Out of these nineteen species, however, as many as ten have been taken in the sub-Antarctic and Antarctic regions and I have indicated these with a † in the lists above. These species may well have been swept southwards from the Atlantic in the North Atlantic Intermediate Current to the sub-Antarctic region, and then have been carried

northwards again in the sub-Antarctic intermediate or the Antarctic Bottom water and so have reached the south-east Pacific area.

Nine species, namely,

Spinocalanus caudatus Sars,
Paraeuchæta incisa (Sars),
P. tumidula (Sars),
Scolecithricella (*Amallophora*) *similis* T. Scott,
Lucicutia curta Farran,
L. longicornis (Giesbr.),
Heterorhabdus compactus Sars,
Isochæta ovalis Giesbr.,
Paraugaptilus buchani Wolfend.,

are, so far as we know at present, confined to the Atlantic Ocean and the eastern Pacific region. It seems very doubtful whether these can be regarded as a relict fauna from the early Tertiary time when there was a direct connection between these two areas, and it seems far more likely that they are rare species and in consequence have only been taken on very few occasions, but that they have followed the same dispersal route as so many other Atlantic species.

The evolution of new species in this south-eastern area of the Pacific Ocean seems to be a matter of extreme rarity, perhaps correlated with the unfavourable character of the water in the 550–1460 m. level (*vide supra*, p. 564) ; I know of only a single species, *Scolecithricella spinacantha* Wilson, that may be regarded as endemic.

When attempting to review the distribution of the pelagic Copepoda of the Antarctic region, it is essential, as Ottestad (1932) has pointed out, to discriminate, so far as our present knowledge will permit, between species that are sub-Arctic and are inhabitants of the West Wind Drift and the Antarctic Intermediate water, and those that are truly Antarctic and may be found in the Antarctic Bottom Drift. It is, I think, justifiable to conclude that the plankton of the West Wind Drift is circum-global in its distribution. I have already (*vide supra*, p. 513) given a list of some 96 species from the North Atlantic that have been taken in the sub-Antarctic and Antarctic regions, and thanks to the work of Brady (1883), Giesbrecht (1902), Wolfenden (1908, 1911), T. Scott (1912), Farran (1929), and Hardy and Gunther (1935), we have records of the following additional species that have been taken in this sub-antarctic zone :

Calanus acutus Giesbr.,
C. propinquus Brady,
C. simillimus Giesbr.,
Drepanopus pectinatus Brady,
Rhincalanus gigas Brady,
Spinocalanus antarcticus Wolfenden,
Euchirella hirsuta Wolfend.,
E. latirostris Farran,
E. spinosa Wolfend.,
Gaidius major Wolfend. (= *brevispinus* Sars),

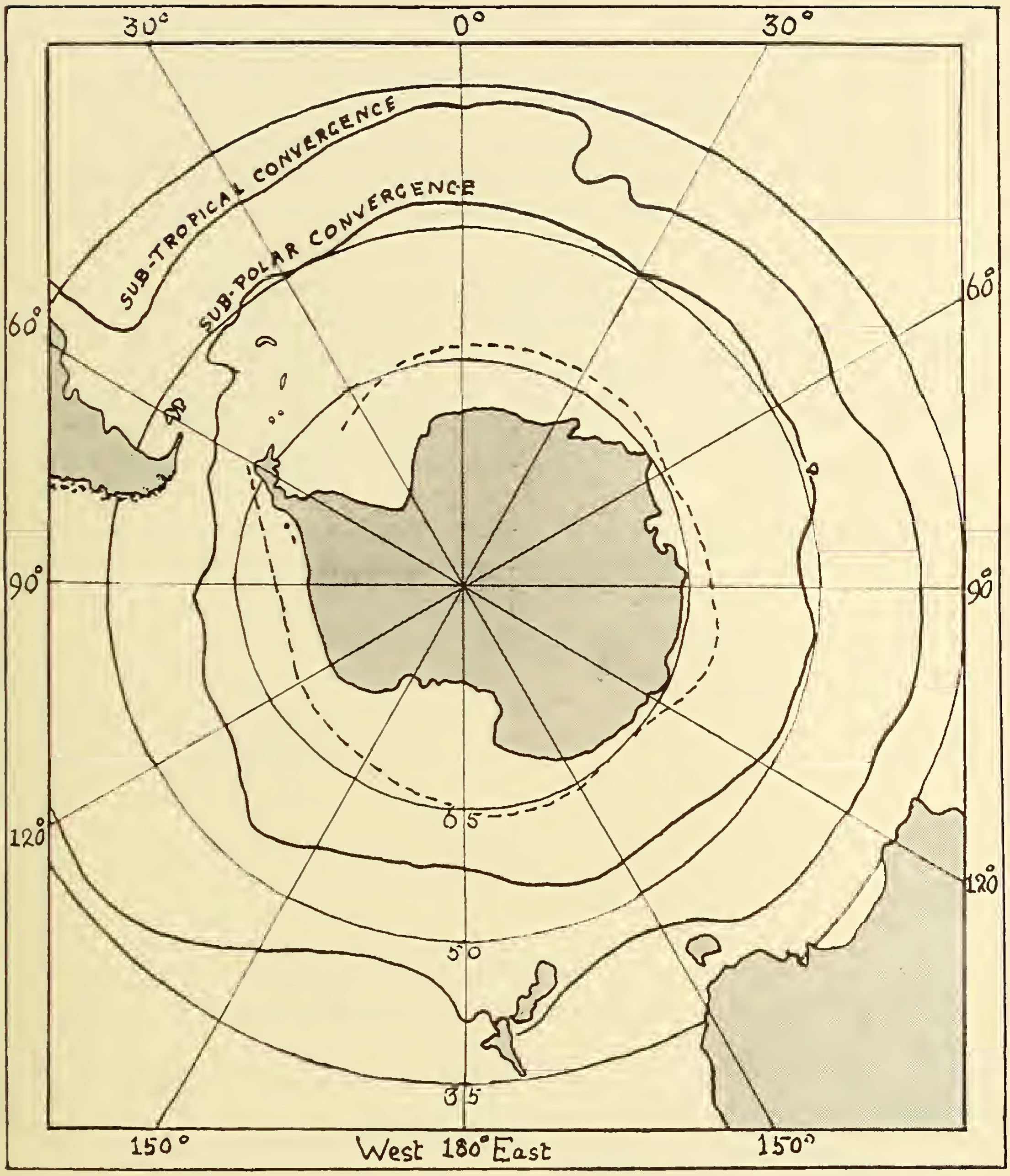
Mesogaidius intermedius Wolfend.,
Paraeuchæta biloba Farran,
Xanthocalanus gracilis Wolfend.,
Scolecithricella echinatus (Farran),
S. glacialis (Giesbr.),
Racovitzanus antarcticus Giesbr.,
Temora kerguelensis Brady,
Lucicutia frigida Wolfend.,
Metridia curticauda Giesbr.,
M. gerlachei Giesbr.,
Heterorhabdus austrinus Giesbr.,
Candacia cheiura Cleve,
Oncœa curvata Giesbr.,

and to these should, perhaps, be added *Heterorhabdus tanneri* Giesbr., *Acartia lilljeborgii* Giesbr., *A. simplex* Sars (if this species be specifically distinct from *A. clausi* Giesbr.), *Cyclopina pusilla* Sars and *Ectinosoma australe* Sars (if this be distinct from *E. melaniceps* Boeck and *E. antarcticum* Giesbr.).

These last three species have been recorded by Sars (1905) from brackish water in Chatham Island in the Pacific Ocean ; this island lies in lat. 44° 20′ S., long. 176° 0′ E. east of New Zealand, and not very far from the northern boundary of the West Wind Drift as indicated by the sub-tropical convergence line.

The water of the West Wind Drift enters the Atlantic Ocean through Drake Passage, and here it becomes mixed with Antarctic water that has been deflected northwards on the west side of Graham Land into the southern side of the Strait, and again as it enters the Scotia Sea the West Wind Drift water is joined by water that is flowing out of the Weddell Sea.

On both the northern and southern sides of the West Wind Drift, that is at both the Sub-tropical and Antarctic Convergence lines (*vide* Text-figs. 94 and 95), there seems to be a considerable mixture of water. At the Sub-tropical convergence line the sub-Antarctic water sinks down and moves southwards underneath the West Wind Drift at a depth of some 80–200 m., and can be followed, at any rate in the South Atlantic Ocean, as far almost as the Antarctic convergence, while in places the sub-tropical water extends southwards above the sub-Antarctic water, thus driving the sub-tropical convergence line towards the south, and Deacon (1937) suggests the possibility that tongues of sub-Antarctic water are occasionally driven across the usual position of the Antarctic convergence line towards the south-east ; but he (1937, p. 35) states that " there is no indication of a movement of sub-Antarctic water southwards over the Antarctic water in the western part of the Indian Ocean." Below the surface of the West Wind Drift there is, between the Sub-tropical and Antarctic convergence zones, a sub-surface current, composed of water derived partly from the sub-Antarctic and partly from sub-tropical water, that tends to flow southwards ; in the Atlantic Ocean this lies at a depth of about 100–150 m., but as we follow it eastward the depth at which this southward current is found gradually increases. In the region to the south of the Cape of Good Hope it lies between 300–400 m. at the northern side and climbs to 100–150 m. at its southern limit ; in the central part of the Indian Ocean it is situated at a depth of 400–600 m., and here is probably largely



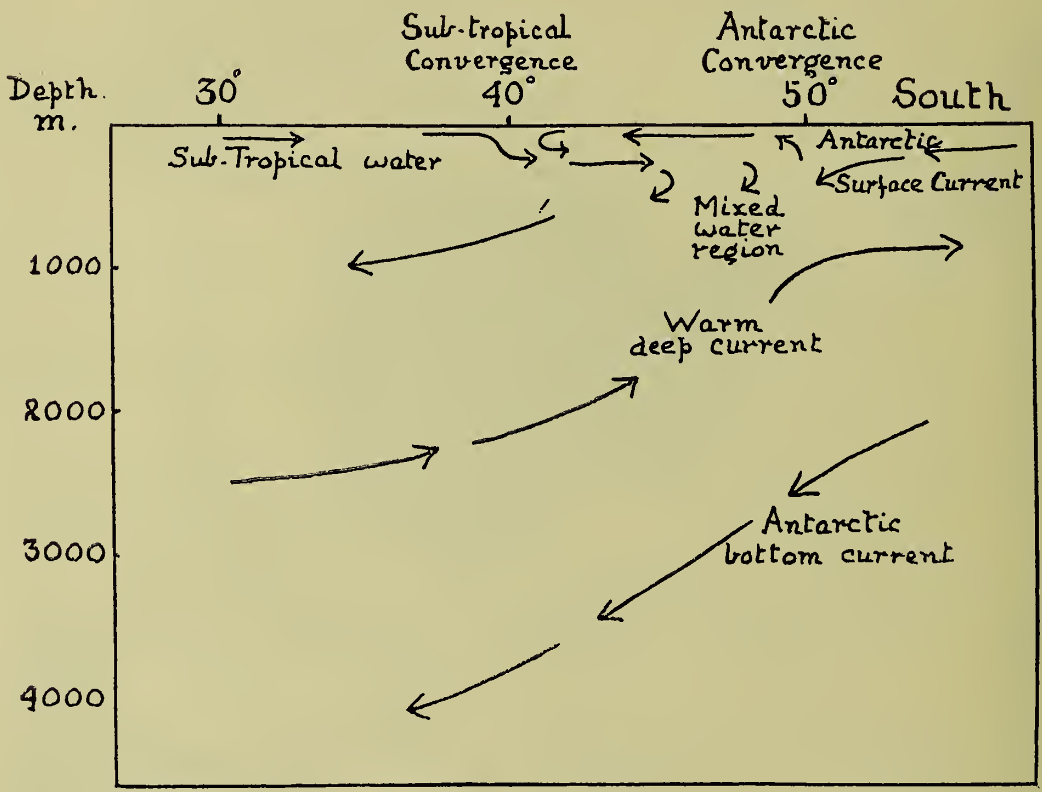
TEXT-FIG. 94.—The Sub-tropical and Sub-polar (Antarctic) Convergence Zones (after Deacon, 1938). – – – – – – – Approximate position of the boundary between the East and West Wind drifts in the Antarctic Zone.

composed of water from the Agulhas Current that has been deflected eastward ; in the Pacific Ocean the strength of this southward flow is considerably reduced and it lies again at a somewhat higher level, namely 300–400 m.

This sub-surface current of sub-tropical water will tend to carry with it tropical and sub-tropical plankton southwards towards the Antarctic convergence beneath the West Wind Drift, and this may perhaps account for the presence of large numbers of such species as *Clausocalanus arcuicornis* (Dana), *Oncæa notopus* Giesbr. and *Scolecithricella*

minor (Brady) at depths of approximately 250–500 m. between lats. 50° and 54° S. in the Atlantic sector of the Antarctic (*vide* Hardy and Gunther, 1935), and the occurrence of *Clausocalanus arcuicornis* (Dana) and *Oncœa* spp. at 385–400 m. and 300 m. respectively in the Indian Sector (*vide* Wolfenden, 1911).

A few species that are definitely Antarctic in their origin appear to have been able to pass northwards across the Antarctic convergence into the West Wind Drift, and Hardy and Gunther (1935) have recorded that a number of species are not limited in their



TEXT-FIG. 95.—The vertical Circulation in the South Atlantic Ocean (after Deacon, 1938).

distribution by this convergence line. The following species have been recorded in the layer between 0 and 250 m. on both sides of the line :

Calanus propinquus Brady.
C. simillimus Giesbr.
Metridia lucens Boeck.
Drepanopus pectinatus Brady.

With regard to the first of these, Hardy and Gunther (1935, p. 356) suggest that there are two separate races, a purely Antartic race and a sub-Antartic one. Other species that are not limited in their distribution by this barrier are :

Calanus acutus Giesbr.
Rhincalanus gigas Brady.
? *Euchirella hirsuta* Wolfend.
Mesogaidius intermedius Wolfend.

Spinocalanus antarcticus Wolfend.
Paraeuchæta antarctica Giesbr.
Scolecithricella glacialis (Giesbr.).
Metridia curticauda Giesbr.
Metridia gerlachei Giesbr.
Heterorhabdus austrinus Giesbr.
Racovitzanus antarcticus (Giesbr.).

In certain species transference across the convergence line into the West Wind Drift appears to be correlated with small changes of structure. Steuer (1932, 1933) has attempted to correlate certain forms of species of *Pleuromamma* with the water masses in which they were living; thus he gives *Pleuromamma quadrungulata* (Dahl), f. *psychrophila* and *P. gracilis* (Claus), f. *maxima* as inhabitants of the West Wind Drift, and Farran (1929, p. 265) has described a variety of *Heterorhabdus austrinus* Giesbr., mainly characterized by its small size, that possesses a habitat extending from the true Antarctic region to as far north as lat. 40° S.

A certain number of species appear to have had their origin in the West Wind Drift. Russell (1935, p. 10) gives the following species as examples of this fauna :

Calanus simillimus Giesbr.,
? *Eucalanus acus* Farran (? = *E. longiceps* Matthews),
Clausocalanus laticeps Farran.
Paraeuchæta biloba Farran,
Candacia cheirura Cleve,

and to these should be added—

Clausocalanus paululus Farran,
? *Drepanopus forcipatus* Giesbr.,
D. pectinatus Brady.
Euchirella latirostris Farran,
Temora kerguelensis Brady,
Copilia hendorfi Dahl.
Centropages aucklandicus Kramer (= *discaudatus* Brady).

and probably—

Heterorhabdus tanneri Giesbr.,
Acartia lilljeborgi Giesbr.

The first of these, *Calanus simillimus* Giesbr., however, is in all probability a true Antarctic species, and the claim of the second, *Eucalanus acus* Farran, depends on whether this species is, or is not, a synonym of *E. longiceps* Matthews, and is the same as the species described by With (1915, p. 52) under the name *Eucalanus attenuatus ?*, which was taken in the North Atlantic Ocean as far north as lats. 57°–61° N.

Ottestad (1932) has put forward the view that only those species that occur in the upper stratum of the Antarctic region, namely the upper 200 m., in which the water is characterized by a salinity of less than 34·5 ‰ and by a negative temperature, should be regarded as truly Antarctic ; those that occur at a greater depth from 200–1500 m., where the water has a higher salinity and a positive temperature, he designates "sub-Antarctic."

It is, however, somewhat doubtful whether this distinction can be maintained, at any rate as regards a number of these southern species, for the work of the "Discovery" (*vide* Hardy and Gunther, 1935) has shown that they may exhibit a very clear vertical migration that is sufficient to carry them out of one stratum into the other. The following species may be regarded as truly Antarctic (*vide* Giesbrecht, 1902; Quidor, 1906; Wolfenden, 1908 and 1911; T. Scott, 1912; Farran, 1929; Hardy and Gunther, 1935; and Wilson, 1938):

Calanus acutus Giesbr.
C. propinquus Brady.
C. simillimus Giesbr. (= *aculeatus* Brady).
Rhincalanus gigas Brady.
Stephus antarcticus Wolfend.
S. longipes Giesbr.
S. neptuni Cleve.
Spinocalanus antarcticus Wolfend.
S. magnus Wolfend.
Drepanopsis frigidus Wolfend.
Chiridius antarcticus (Wolfend.) (= *Faroella antarctica* Wolfend.).
C. minor (Wolfend.) (= *Faroella minor* Wolfend.).
C. polaris Wolfend.
Pseudochirella elongata (Wolfend.).
Euchirella rostromagna Wolfend.
E. elongata Wolfend.
Gœtanus antarcticus Wolfend.
Chirundina antarctica Wolfend.
Paraeuchœta antarctica (Giesbr.).
P. austrina Giesbr.
P. erebi Farran.
P. rasa Farran.
P. similis (Wolfend.).
Xanthocalanus antarcticus Wolfend.
X. gracilis Wolfend.
X. tenuiserratus Wolfend.
Onchocalanus frigidus Wolfend.
Cephalophanes frigidus Wolfend.
Scolecithrix polaris Wolfend.
S. glacialis Giesbr.*
S. incisa Farran.
Scaphocalanus impar (Wolfend.) (= *Amallophora impar* Wolfend.).
S. sub-brevicornis (Wolfend.) (= *Amallophora sub-brevicornis* Wolfend.).
Amallophora altera Farran.
Racovitzanus antarcticus Giesbr.
Metridia curticauda Giesbr.

* According to Brady (1918, p. 23) this species is synonymous with *Scolecithrix römeri* Mrazek that has been recorded from the Arctic Ocean; if this be the case, the species is bipolar in its habitat.

M. gerlachei Giesbr.
Lucicutia frigida Wolfend.
Heterorhabdus austrinus Giesbr.*
H. pustulifer Farran.
Euaugaptilus antarcticus (Wolfend.).
E. cornutus (Wolfend.).
Haloptilus ocellatus Wolfend.
Paralabidocera antarctica (Thompson) (= *hodgsoni* Wolfend.).
Temoropsis simplex Wolfend.
Oithona frigida Giesbr.
?*Oncæa curvata* Giesbr.

In addition to the above, Brady (1918) has described several new genera and species from the collections made by the Australian Antarctic Expedition, 1911–14, but in a number of cases it appears highly probable that he was dealing with immature examples, and many of his descriptions are so inadequate that it is impossible, without a careful examination of the material, to determine whether his new genera and species can be accepted. A list of these species is given below :

Diarthropus torticornis gen. nov., sp. nov.
Spinocalanus giesbrechti sp. nov.
Streptocalanus typicus gen. nov., sp. nov.
Gætanus antarcticus sp. nov. (*non* Wolfenden).
Gaidius glacialis sp. nov.
Euchirella plumosa sp. nov.
E. tumida sp. nov.
Paraeuchæta plumifera sp. nov.
Euchætopsis haswelli gen. nov., sp. nov.
Pseudoothrix anatina gen. nov., sp. nov.
Plagiopus australis gen. nov., sp. nov.
Metridia andræna sp. nov.
M. trispinosa sp. nov.
Pleuromamma wolfendeni sp. nov.
Heterorhabdus farrani sp. nov.
H. nigrocinctus sp. nov.
Stephus simillimus sp. nov.

Ottestad regards *Calanus acutus* Giesbr., *Calanus propinquus* Brady and *Metridia gerlachei* Giesbr. as true Antarctic species, whereas *Calanus simillimus* Giesbr., *Rhincalanus gigas* Brady and *Metridia curticauda* Giesbr. he regards as sub-Antarctic. Lying below the water of the West Wind Drift there is, as already mentioned, a sub-surface southward-moving mass of water, composed in part of a return current of sub-Antarctic water and in part of sub-tropical water (*vide* Text-fig. 95) ; this return current can be detected in all

* Farran (1929, p. 265) seems to doubt whether this species can be regarded as distinct from *H. norvegicus* Boeck. He remarks, " the females scarcely differ except in their slightly larger size from the North Atlantic species which I have referred (1908, 1926) to *H. norvegicus* " ; and as regards the male, he notes that " they do not differ in any noticeable degree from those of *H. norvegicus*." There are slight differences in the 5th legs of both sexes between these two species.

three oceans, though it lies at somewhat different levels in each, and in places it reaches to within 100 miles of the Antarctic convergence. At its southern extremity this current meets with a mass of true Antarctic surface water that is moving northwards, and is sinking down at the Antarctic convergence line to form the Antarctic Intermediate Current that flows northwards above the southwardly-moving warm Intermediate water from the northern and tropical regions of the three oceans, Atlantic, Indian and Pacific. The strength of this Antarctic Intermediate Current varies very considerably in the different oceans (*vide* Chart II) ; in the Atlantic it flows northwards past the Equator, flowing up the western side and then spreading out eastward across the South Atlantic into the Gulf of Guinea, while a weaker branch flows northwards towards the south-west point of Africa (*vide* Wüst, 1936, fig. 5) ; in the Indian Ocean it also flows northwards in the main on the western side of the ocean, and reaches as far as the Gulf of Oman, but on the eastern side it seems to vary very considerably in strength. The " Snellius " expedition found it to be strongly developed in the equatorial region on the eastern side, but the " Dana " expedition found no trace of it in lat. 5° N. Steuer (1933, p. 296) states that Defant informed him that this Intermediate current is absent in the Bay of Bengal, and on this he bases his explanation of the presence of large examples of *Pleuromamma xiphias* (Giesbr.), that are characteristic of the Antarctic Intermediate water, in the Arabian Sea and their absence from the Bay of Bengal. In the Pacific Ocean the Antarctic Intermediate water reaches on the western side as far as the equator or even lat. 16° N. Below the warm Intermediate Current lies the Atlantic Bottom Drift, but the most recent work on this deep current (*vide* Deacon, 1938) indicates that this mass of water has a single origin in the Weddell Sea, and that, sinking down in this area, it flows steadily eastward and northward through all the three oceans, mixing as it goes with water from other sources such as the Atlantic and Indian Intermediate Currents. In the Atlantic Ocean this bottom drift passes up the western basin as far as lat. 40° N., and a branch enters the eastern basin through the Romanche Channel near the Equator and then spreads northwards as far as lat. 35° N. and southward to the Walfisch Ridge in lat. 20°–35° S. Another branch passes northwards in the eastern part of the south Atlantic between the tip of the Mid-Atlantic Ridge and the Crozet Bank and spreads out south-west of Africa as far as the Walfisch Ridge. In the Indian Ocean one mass of Antarctic bottom water flows northwards between the Crozet Bank and the Kerguelen-Gaussberg Ridge and flows northwards up the western series of basins into the Arabian Sea, while a second mass passes north on the east side of the Kerguelen-Gaussberg Ridge into the eastern basin and the Bay of Bengal. In the Pacific Ocean the Antarctic Bottom water has become mixed with Atlantic and Indian Intermediate water flowing eastward past the south of Australia, and then this combined mass spreads eastward and northward.

It thus seems clear that while the species that inhabit the region of the West Wind Drift may be swept northwards towards the Equator in the Antarctic Intermediate water, the true Antarctic species may be carried in this direction by either the Antarctic Intermediate water or by the Antarctic Bottom Drift. According to Farran (1929, p. 291), *Copilia hendorfi* Dahl " seems to have a continuous distribution from New Zealand by way of Australia to South Africa " ; I should prefer to place these regions in the inverse order, and regard the distribution as extending from South Africa past Australia to New Zealand. Reference to the chart of its distribution given by Lehnhofer (1926, p. 165) shows that in the majority of instances this species has been taken between lats. 20° and

40° S., and most, if not all, of these catches appear to have been made in the uppermost few metres, but Steuer (1933, p. 289) states that examples were taken in the Indian Ocean at "Valdivia" Sta. 170 in lat. 32° 54′ S., long. 83° 02′ E. at a depth of 1750–1000 m., and among the "John Murray" collections was an example taken at Sta. 131 in lat. 1° 39′ 06″ S., long. 61° 13′ 48″ E. in a haul between 500–0 m. Both these last depths correspond to the Antarctic Intermediate Current. Other records of the presence of species that are known to be inhabitants of the West Wind Drift considerably to the north of this current have been given by Cleve (1904): he has recorded *Candacia cheiura* Cleve from the region of the Benguela Current at a depth between 275 and 450 m., and in the south-western part of the Indian Ocean beneath the Agulhas current of *Heterorhabdus austrinus* Giesbr. at a depth of 530–780 m., and *H. tanneri* Giesbr. at 900 m. depth.

Steuer (1933, p. 296) has suggested that Antarctic copepods can pass far to the north into tropical regions through the action of the Antarctic Deep current: this may be true of a few species, but a study of the depths at which these Antarctic species have been taken seems to render it more probable that the greater number have been distributed northwards by the agency of the Antarctic Intermediate Current. A number of Antarctic species have been taken far to the north in various regions of all three great oceans. One such region lies to the west and south-west of the Cape of Good Hope in the South African "Mischgebiet": here Cleve (1904) recorded *Stephos neptuni* Cleve at a depth of 250–350 m., and, if Wolfenden (1911) be correct in his assumption that the form recorded by Cleve from this region under the name *Metridia lucens* Boeck was in reality *M. gerlachei* Giesbr., this species, too, has been taken here in a depth of only 250–450 m. In the same area *Metridia curticauda* Giesbr. was taken by the "Valdivia" in depths of 1000 and 3000 m., *Rhincalanus gigas* Brady in a depth of 1200 m., and both *Euchirella hirsuta* Wolfend. and *Mesogaidius intermedius* Wolfend. in a depth of 3000 m. *Metridia curticauda* Giesbr. has been recorded from lat. 12° 11′ S., long. 6° 11′ W. at a depth of 2000 m., and from lat. 20° 44′ N., long. 31° 54′ W. at the same depth, and Wilson (1942) has reported it at "Carnegie" Sta. 6, lat. 50° 22′ N., long. 13° 31′ W., at the surface, but this last record is, I think, open to doubt. *Calanus propinquus* Brady was reported by the "Challenger" at Sta. 342, lat. 9° 43′ S., long. 13° 51′ W., and at Sta. 348, lat. 3° 10′ N., long. 14° 51′ W., in both instances at the surface, and Wilson (1942) has recorded it from the Caribbean Sea as far north as lat. 15° 15′ N., long. 68° 11′ W. in the top 100 m.

As just mentioned in the case of *Metridia curticauda* Giesbr., the reports of several Antarctic species being taken far to the north in the Atlantic Ocean have been regarded of doubtful reliability. Giesbrecht (1902) has already called attention to the probability that *Calanus propinquus* (Brady) and *C. simillimus* Giesbr. have been confused with each other, and Wolfenden (1911) states that according to the results obtained by the "Gauss" *propinquus* is not found west or north of the Cape of Good Hope. This latter author also considers that *Rhincalanus grandis* Giesbr. does not extend beyond this region, such records as have been made of its occurrence further to the north being due to a confusion with large examples of *Rhincalanus nasutus*, which were named *Rhincalanus gigas* by Brady and were taken in lat. 37° 17′ S., long. 53° 52′ W., and again in lat. 36° 44′ S., long. 46° 16′ W. at the surface by the "Challenger" (*vide* Brady, 1883, p. 42). I see no reason to doubt the correctness of Brady's identification, and Steuer (1933, fig. 7, p. 289) has accepted them as true records of this species, *R. gigas* Brady and *R. grandis* Giesbr. being synonyms.

Drepanopsis frigidus Wolfend. has been reported from lat. 0° 46′ N., long. 18° 59′ W. at a depth of 3000 m. ; and *Drepanopus pectinatus* Brady has been reported by Wilson (1942) as far north as lat. 44° 39′ N., long. 33° 06′ W. at 100 m. Reference to the section given by Wüst (1935, pl. xxvii) of the salinity of the water on the two sides of the Atlantic Ocean shows that not one of these records is from sufficient depth to fall within the limits of the Antarctic Bottom Drift, and the fact that several of them are from the surface or the top 100 m. clearly suggests that the transfer northwards from the Antarctic region has been by the Antarctic Intermediate Current, from which by the action of turbulent movement of the water specimens have been brought up from below : this would be in conformity with Iselin's view (*vide supra*, p. 492) that water of the Antarctic Intermediate Current may join the Gulf Stream.

In the Indian Ocean the region round Kerguelen Island appears to be an area in which Antarctic species are to be found : *Calanus propinquus* Brady, *Spinocalanus antarcticus* Wolfend. and *Mesogaidius intermedius* Wolfend. have been taken here at a depth of 1200 m., and *Rhincalanus gigas* Brady has been reported here at only 70 m. depth. This last species occurs considerably further north, and has been recorded in lat. 26° 04′ S., long. 93° 44′ E. at a depth of 2200 m., in lat. 4° 06′ S., long. 73° 25′ E. in 2000 m., and in lat. 9° 06′ N., long. 53° 41′ E. in 1500 m. It is interesting to note that the depth of occurrence gets progressively less as we pass northwards. *Metridia gerlachei* Giesbr. has been recorded in lat. 24° 47′ S., long. 58° 29′ E. in 3000 m. *Drepanopsis frigidus* Wolfenden and *Metridia curticauda* Giesbr. have been able to cross the Equator, and both were taken at " Investigator " Sta. 682 in the Laccadive Sea (lat. 10° 26′ N., long. 74° 32′ 30″ E.) in a haul from 1280 m. (700 fms.) to the surface, and the " John Murray " Expedition obtained examples of *Gœtanus antarcticus* Wolfend. as far north as lat. 24° 10′ 36″ N., long. 59° 00′ 36″ E. in a haul from 2500 m. As regards this last record, the mass of water in which the capture was made has been shown by Mohamed (1940, pp. 159 and 172) to be part of the Antarctic Intermediate Current. Steuer (1926*b*), in his account of the genus *Cephalophanes*, shows that whereas *C. refulgens* Sars is an Atlantic form that occurs between lats. 55° N. and 30° S., the second species in the genus, *C. frigidus* Wolfenden, is an Antarctic species that has been carried northwards. In this paper he suggests that examples are carried along in the Atlantic Ocean in the Antarctic Intermediate Current and in the Indian Ocean in the Antarctic Bottom Drift. In a later paper (1933) he again attributes the presence of *C. frigidus* in the Indian Ocean to the Antarctic Bottom Drift, but he now suggests that the presence of this species in the Atlantic Ocean in the region of the Gulf of Guinea is due to " the strong outflow of water from the Indian Ocean into the Atlantic that is brought about down to about 1500 m. by the Agulhas Current." I have already pointed out that the existence of this deep current flowing from the Indian Ocean towards the Weddell Sea in the Antarctic is no longer accepted, and it would appear to be much more probable that examples may be swept northwards into both the Atlantic and Indian Oceans by either the Antarctic Intermediate Current or by the Antarctic Bottom Drift. In the " Valdivia " collection examples were taken in the Indian Ocean at Sta. 232, lat. 3° 26′ N., long. 58° 35′ E. in a vertical haul from 1500 m. and this lies in the Antarctic Intermediate Current ; other examples were taken at Sta. 215 at the southern end of the Bay of Bengal, lat. 7° 01′ N., long. 85° 57′ E. in a vertical haul from 2500 m., and if these specimens came from the extreme depth this would correspond better with the Antarctic Bottom Drift, especially in view of the doubt whether the Antarctic Inter-

mediate Current extends so far to the north in this region. In the Atlantic Ocean the region from which examples were obtained lay in the Gulf of Guinea, at Sta. 46, lat. 1° 25′ N., long. 10° 16′ W., in a vertical haul from 3000 m., Sta. 49, lat. 0° 20′ N., long. 6° 45′ W., in a vertical haul from 3500 m., and near the region of the south African "Mischgebiet," lat. 31° 21′ S., long. 9° 46′ E., in a vertical haul from 3000 m. These depths seem to indicate that the species was living at a depth too great to be in the Antarctic Intermediate Current, and it thus seems probable that in this ocean they were swept northwards by the Antarctic Bottom Drift: their presence in the Gulf of Guinea could well be accounted for by the flow of Antarctic Bottom water from the western Atlantic Basin through the Romanche Channel.

In the Pacific Ocean Brady has recorded *Calanus propinquus* Brady from lat. 35° 41′ N., long. 157° 42′ E. at the surface, and Wilson (1942) reports its presence throughout the Pacific Ocean in the top 100 m. between lat. 16° 35′ S., long. 155° 44′ W., and lat. 40° 20′ N., long. 150° 58′ E. Brady (1883) has recorded *Rhincalanus gigas* Brady from the North Pacific Ocean as far north as lat. 35° N. between Japan and Honolulu, but this is almost certainly wrong, and he was probably dealing with examples of *Rhincalanus nasutus* Giesbr.

Finally *Oncaea curvata* Giesbr. has been recorded by Wilson (1942) at several "Carnegie" Stations between lat. 1° 32′ S., long. 93° 10′ W., and lat. 6° 32′ N., long. 80° 04′ W. at a depth of only 100 m. Farran states that this species is frequent in the Antarctic, especially under the ice at Winter Quarters, and extending northwards as far as 58° 30′ N. (sic); this must, I think, be a printer's error for 58° 30′ S.

In all these records the depth of occurrence that is given for any particular catch is the maximum at which the animal might have been living when the haul was made, and the actual habitat may have been in considerably shallower depths. With the exception of the species *Cephalophanes frigidus* Wolfend., in no instance is the depth sufficiently great to have brought the animal into the track of the Antarctic Bottom Drift, and in many instances the depth clearly corresponds either to the Antarctic Intermediate Current, or to the upper stratum of the North Atlantic or Indian Intermediate Current lying just below it, and thus corresponds reasonably closely with the depth at which, as we have already seen (*vide supra*, p. 328), the great majority of the deep-dwelling Copepoda are found. It is also significant that the majority of the Antarctic species that have been taken far to the north of the Antarctic region and in deep water north of the Antarctic convergence zone are those that, as we have seen, are able to withstand the changes encountered in a transfer from true Antarctic conditions to those that are characteristic of the West Wind Drift.

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CHART 1

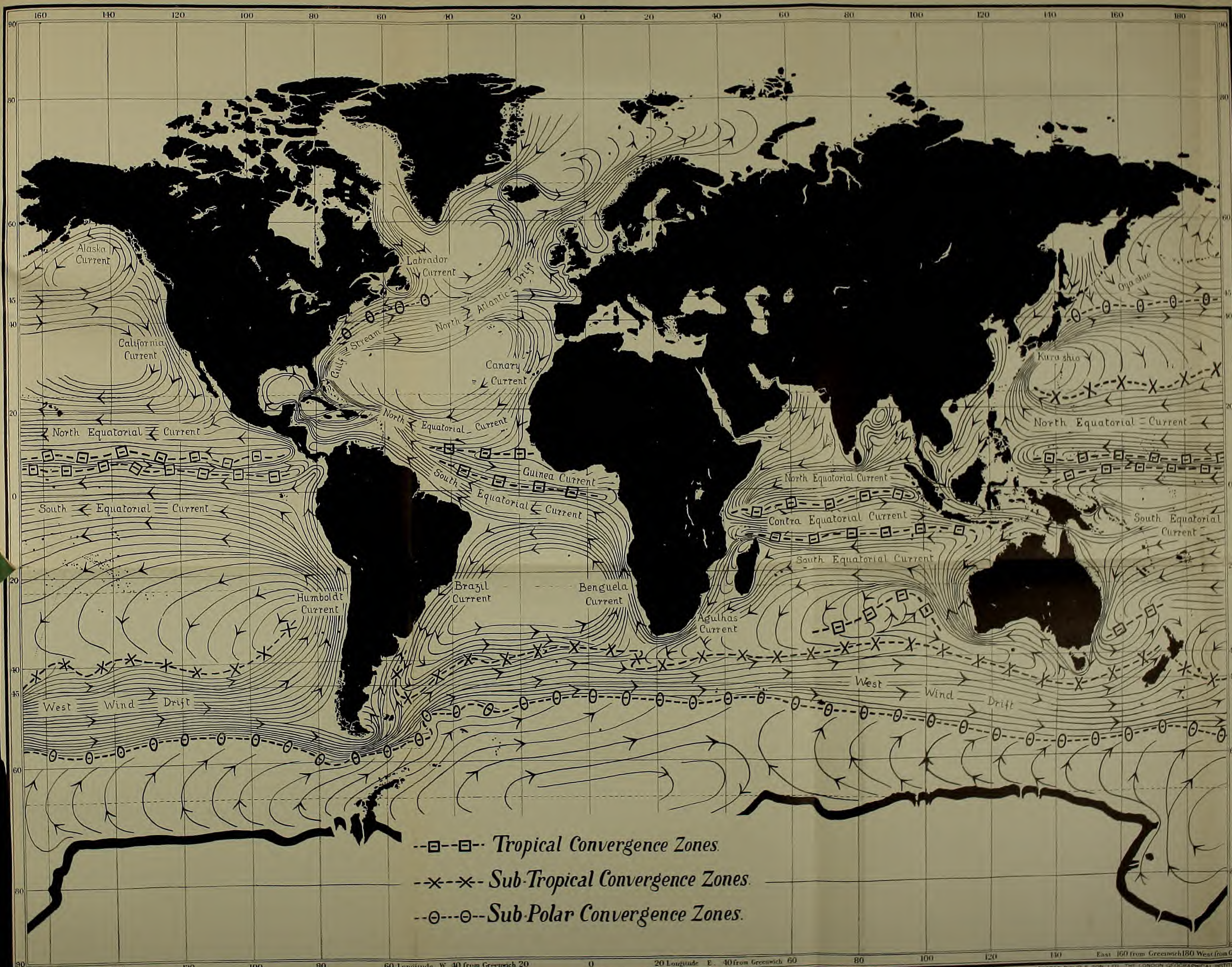

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CHART 2


THE MAIN TRENDS OF THE DEEP OCEAN CURRENTS.
Sub. Polar Intermediate.
North Atlantic Intermediate.
Indian & Pacific " "
Antartic Bottom Drift.
60 Longitude W. 40 from Greenwich 20
20 Longitude E. 40 from Greenwich 60
East 160 from Greenwich 180 West from G.
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